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Management of passive countersurveillance in the R & D environment

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MANAGEMENT OF PASSIVE COUNTERSURVEILLANCE

IN THE R&D ENVIRONMENT

by

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ABSTRACT

Existing management procedures that are pertinent to research and development activities within the Government are presented. The main focus of this effort is on the Mobility Equipment Research and Development Center's Countersurveillance and Topographic Division, and highlights the relevant plans, documents, programs, and reporting systems utilized by the Army and the Department of Defense. An in-depth examination is made on the need for Countersurveillance in the Army. The Army's existing Countersurveillance research and development missions and programs are reviewed.

A detailed investigation and analysis is performed on current management concepts and techniques that are utilized in research and development endeavors. Those administrative procedures that are directly applicable to the Countersurveillance and Topographic Division and its environment are specifically discussed. The main activities covered in this managerial evaluation are: planning, organizing, staffing, directing, and controlling.

ACKNOWLEDGEMENT

Acknowledgement is due many people who have made this work possible. The author would like to express his sincere appreciation to Dr. Henry Weibe of the University of Missouri-Rolla and to Mr. John Hopkins of the Mobility Equipment Research and Development Center. Their criticisms and suggestions have provided a deeper understanding of the problem and its solution. Indebtedness is also owed to those U.S. Army personnel who participated in the interviews and gave generously of their time and experience. Finally, the author expresses his gratitude to his wife, Anne, for her understanding and help in the preparation of this paper.

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I. INTRODUCTION

The purpose of this thesis is to formulate selected managerial concepts and techniques that are applicable to United States Army Mobility Equipment Research and Development Center's Countersurveillance and Topographic Division. It is anticipated that these management methods will be utilized in increasing the overall effectiveness of MERDC's countersurveillance efforts during the mid-70's.

A. Background

For many years little emphasis was placed on camouflage as compared to various Surveillance, Target Acquisition, and Night Observation programs. This large discrepancy in interest and resource allocations resulted in increasing the capabilities of reconnaissance, surveillance, and intelligence (RS&I) systems to the point that a country's military posture at a given point in time could be determined in a relatively short time period. This sensor capability generated the need to enhance the military's ability to degrade the effectiveness of RS&I systems of an existing or potential opposing force.

In order to meet this challenge as quickly as possible, an intensified research and development program in camouflage began in the early part of 1972. Consequently, the Department of the Army designated the U.S. Army Mobility Equipment Research and Development Center (MERDC) located at Fort Belvoir, Virginia, the lead laboratory for camouflage technology. To carry out this in depth effort within MERDC, the Countersurveillance Branch was expanded into a division (doubling in manpower) and budgetary funding was increased more than five times from its original level of one million dollars per year. This rapid expansion in manpower and funds has generated a new emphasis on management of the existing countersurveillance resources to insure their efficient utilization.

B. Problem and Approach

The Countersurveillance and Topographic Division was given prime responsibility in conducting and supervising all camouflage research, development, testing, and evaluating activities. These efforts include camouflage against all militarily significant approaches to remote sensing; in particular, the electromagnetic spectrum from ultra-violet through radar wave lengths. This effort required managers, as well as employees, to become more involved with the many different aspects of the countersurveillance environment. These aspects included: an understanding of the Army's R&D management policies and procurement procedures; an appreciation of the existing and potential military threat and resulting requirements; a knowledge of the Department of Defense, as well as allied nations pertinent programs and organizations; a comprehension of the capabilities of the men and materials that are available in government in-house laboratories; a technical insight into the nature and solution of countersurveillance problems, and most importantly, the ability to separate the management functions from the technical requirements and create an environment that is conducive to R&D efforts at the project work level.

The approach taken in this thesis is to first review the existing management procedures in government especially with the Department of the Army: secondly, to synopsis the potential military threat and Army field requirements in camouflage; next, to review the countersurveillance activities currently being performed at the laboratory level; and lastly to analyze the existing management techniques that are applicable to MERDC and its existing environment. Thus the reader hopefully will gain an appreciation of the complexity of the administrative problems and will obtain a general understanding of the critical factors that makes the selection of a specific management approach possible. The main thrust of the management methodology presented is centered on the project engineer in order to increase his productivity through improved decision making methods, more efficient use of the computer, and a more compatible relationship with his supervisors. However, these managerial approaches must have the active support of the first line and immediate supervisors for effective implementation.

It is felt that this paper can also be utilized as a quick reference manual to determine a persons or company's interest in the countersurveillance field. Furthermore, it could be employed to enlighten in-house personnel of the scope of countersurveillance activities to include use as an orientation reference manual for new employees.

This paper does not contain classified information for several reasons. First, a classified report severely limits the number of people that could have access to it, as well as hindering authorized personnel. Secondly, it is believed that the unclassified data given is adequate to gain an understanding of the management techniques developed herein. Lastly, the emphasis on any individual classified project changes within a relatively short time as compared to the general technological field.

II. REVIEW OF EXISTING MANAGEMENT PROCEDURES

A. Government Management System

The integrated Planning-Programming-Budgeting System (PPBS)[1] is the master concept of management in government today. PPBS integrates the systems required to delineate an agency's missions, to consider alternative missions and courses of action, and to specify the activities and resources required to achieve those mission objectives. The PPBS for each agency embodies a classification and coding structure that reflects the major activities, programs or missions and relates the appropriate systems, subsystems, or supporting activities to them. The major classifications (program categories, program subcategories, program elements) are used for agency PPBS and appear in all documentation related to each of these activities at every level of program initiation, approval, and change. Currently, the Department of Defense (DOD) utilizes the PPBS as a flexible tool for its Five-Year Defense Program (FYDP).

Perhaps the biggest influence on the PPBS is the Federal budget cycle. The starting date for budget preparation varies from agency to agency. The DOD begins formal preparation sixteen months prior to what is referred to as either the subject year or the budget year. Actual preparation precedes this by several months. After many months of continuous exchange of information among the President, the Office of Manpower and Budget, and the various government agencies, the President's budget proposals are submitted to Congress in January. Beginning in the spring, each agency evaluates its programs, identifies policy issues, and makes budgetary projections, giving attention both to important modifications and innovations in its progress based upon the approved executive budget. After review by the agency and the Office of Manpower and Budget, these studies, evaluations, and projections form the basis for the budget policy guidelines and the preparation of next year's budget. These budget guidelines from the basis of the PPBS for the Department of Defense and in turn the Department of the Army which are discussed in the next two sections.

B. Department of Defense

This section deals with the Planning-Programming-Budgeting System and other management processes of the Department of Defense (DOD). These include the major actions of the Office of the Secretary of Defense (OSD) the Joint Chiefs of Staff (JCS), and the Director of Defense Research and Engineering, (DDR&E). Department of the Army regulations that are applicable to this section are presented in Appendix A for reference.

Guidelines for DOD programs are provided by the National Policy. This policy is derived from many influencing factors such as: Presidential correspondence; National Security Council deliberations; intelligence estimates relating to our enemies or allies; and national and international social, political, economic, military factors. Specific program requirements originate through a recognition of some deficiency in DOD by government or industry people responsible for threat analysis or by people responsible for operations in the field. Generally speaking, a requirement document necessary for program initiation will be produced when a technological opportunity appears, when potential enemies are developing equipment superior to ours, or when there is a general consensus that equipment in the field will soon be obsolete.

1. Structure

The foundation of the DOD planning and programming system is the Five-Year Defense Program (FYDP) which is the summation of all DOD components and their approved programs. The FYDP provides continuity and visibility into long-range programs (current fiscal year plus eight years) for forces and the current fiscal year plus five years in terms of manpower and resources. In summary, the FYDP unites all facets of the defense effort together by relating national security objectives to strategy, strategy to the forces required, forces to resources, and resources to costs, all within the same conceptual framework and all projects several years into the future. It also provides the means for review and approval of DOD programs and changes to previously approved programs.

The DOD programming system organizes all defense activity into eleven DOD-wide programs (see Figure 1) which are organized essentially on a mission-oriented basis. Each of the eleven major programs is subdivided into program elements whose mission characteristics are closely related. DOD programs one through six and seven to eleven normally fall within the purview of the Assistant Secretary of Defense for review and recommendations regarding resource assignments. However, Program VI is assigned to the Director Defense Research and Engineering (DDR&E). None of the programs are the exclusive responsibility of the stated groups since many programs and elements overlap areas of management responsibility.

I. Strategic Forces

II. General Purpose Forces

III. Intelligence and Communications

IV. Airlift and Sealift

V. Guard and Reserve Forces

VI. Research and Development

VII. Central Supply and Maintenance

VIII. Training, Medical and Other General Personnel Activities

IX. Administration and Associated Activities

X. Support of Other Nations

XI. Undistributed Adjustments

Figure 1. DOD Programs Structure

Program VI is further organized into specific categories to facilitate planning, programming, budgeting and managing the Research Development Test and Evaluation (RDTE) activities. These six categories are defined as follows:

a. Research (6.1). Includes all effort directed toward increasing knowledge and understanding of natural phenomena. This generally includes all basic research and applied research directed toward the expansion of knowledge in various scientific fields. It provides the fundamental knwoledge for the solution of identified military problems.

b. Exploratory Development (6.2). Includes all efforts directed toward the solution of specific military problems short of major development efforts, with a view to developing and evaluating the technical feasibility and practicability of proposed solutions and determining their parameters. This type of effort may vary from fairly fundamental applied research to quite sophisticated prototype hardware, study, and planning efforts.

c. Advanced Development (6.3). Includes all projects which have moved into developing hardware for experimental or operational tests. Design effort is directed toward hardware for suitability as opposed to items designed and engineered for eventual service use.

d. Engineering Development (6.4). Includes all efforts identified for those development programs being engineered for service use but that have not been approved for procurement or operations. This area is generally characterized by major line item projects, and program control is exercised by reviewing individual projects.

e. Management and Support (6.5). Includes all projects directed toward support of installations or operations required for research and development use. It includes in-house research and development; operation and maintenance of related R&D installation and facilities; and military construction not specifically identified with program elements in other categories.

f. Operational System Development (6.7). This category is not defined as an R&D category in the FYDP program element structure. It represents a convenient grouping of major line item projects which appear as the RDTE cost of weapon system elements funded in programs other than program VI.

The categories of Program VI are further subdivided into specific elements, each consisting of RDTE projects. Each element may be one major project, or it may be a number of related projects in a particular field of research or development. In order to control the elements within these programs, as well as other programs, DOD has developed a program element classification system. This system is the controlling tool for structuring and relating all manpower, funds, and facilities throughout the DOD. It consists of a six-digit numbering system as shown in Figure 2. The first digit identifies the major DOD program, the second digit identifies the category of research, the third digit identifies the RDTE Budget activity, the next two digits identify the project and the last indicates the military service concerned.

6 . 47 . 17 . A

DOD PROGRAM
1. Strategic Forces
2. General Purpose Forces
3. Intelligence and Comm.
4. Airlift and Sealift
5. Guard of Reserve Forces
6. Research and Development
7. Central Supply and Maint.
8. Training, Medical and Other General Personnel Activities
9. Administration and Associated Activities
0. Support of Other Nations

CATEGORY
6.1 Research
6.2 Exploratory Development
6.3 Advance Development
6.4 Engineering Development
6.5 Management and Support

BUDGET ACTIVITY
6 x 0 R&D Support From Other Appropriations
6 x 1 Research (Military Sciences)
6 x 2 Aircraft & Related Equipment
6 x 3 Missiles & Related Equipment
6 x 4 Mil Astronautics & Related Equip.
6 x 5 Ships, Small Craft & Related Equip.
6 x 6 Ord, Cmbt Vehicles & Related Equip.
6 x 7 Other Equipment
6 x 8 Management & Support

DOD COMPONENT
A - Dept. of the Army
C - Office of Civil Defense
D - Dept of Defense
F - Dept of Air Force
G - National Security Agency
H - Defense Atomic Support Agency
J - Joint Chiefs of State
K - Defense Communications Agency
L - Defense Intelligence Agency
M - United States Marine Corps
N - Dept of the Navy
R - Defense Contract Audit Agency
S - Defense Supply Agency

SERIAL NUMBER
(In combination with second and third digit identifies a specific program element.)

Figure 2. DOD Program Element Code System

2. Planning/Budget Cycle

The DOD planning phase identifies objectives and goals based upon special studies and analysis of the security of the United States. This phase is initiated by the Office of the Secretary of Defense (OSD) issuing the Defense Policy and Planning Guidance Memorandum (DPPG) which is based upon guidance from the Joint Chiefs of Staff. Each DOD component in turn reviews the DPPG and submits their recommendation to OSD. With the issuing of the Program Decision Memorandum (PDM) by the OSD, the Five-Year Defense Program (FYDP) is finalized and missions are specified to all commands to be used as guidance in their budget estimates. It should be noted that research, development, test and evaluation activities are managed for OSD by the Director of Defense Research and Engineering (DDR&E).

The Joint Chiefs of Staff have a large role in determining the scope of military forces and supporting activities and their impact on the eventual program and budget. The joint documents of greatest significance are: Joint Long Range Estimates Intelligence Document (JLREID): Joint Strategic Objectives Plan (JSOP); Joint Research and Development Objectives Document (JRDOD) and Joint Strategic Capabilities Plan (JSCP).

The DOD PPBS is applicable to a specific project, a program element, or an entire research and development program. Thus, for either a project or the entire program, it is psossible to identify the plan that established the goals and the program to allocate and schedule the resources over a period of years. PPBS documentation common to all of the services are the DD Form 1498, Research and Technology Resume, and the Technical Development Plan. Either a DD

Form 1498 or a Technical Development Plan exists for each program element, project, task area, and work unit approved in the Five-Year Defense Program.

DOD planning, programming and budgeting activities are continuous but conform as much as possible to the budget cycle. The DOD activities in the federal budget cycle are shown in Figure 3.[2(p. 101)] A brief synopsis of the budget cycle follows:

About fifteen months before the beginning of the fiscal year (1 July), the Office of the Secretary of Defense (OSD) issues fiscal guidance to the military departments. Final guidance for the preparation of budget estimates is contained in the Program Decision Memorandum. In accordance with this guidance, the departments develop and submit their budget estimates to OSD in October. After OSD review and approval, the consolidated budget estimate is sent to the Office of Management and Budget (OMB). There it is incorporated into the President's budget message, which is sent to Congress in early January, six months before the fiscal year of execution begins.

During the spring, Congress, through its committees holds hearings at which the Secretary of Defense, his staff, and representatives of the military departments testify in support of their budget request. Meanwhile, the military departments prepare apportionment requests containing updated program information and fiscal data. In June, the DDR&E and the Comptroller request and recommend the schedules for programmed obligation of the funds to OMB. As soon as possible after 30 June, the Congress authorizes the effort represented by the budget request and appropriates funds to support it. Then the OMB appropriates those funds in accordance with the requests submitted by various

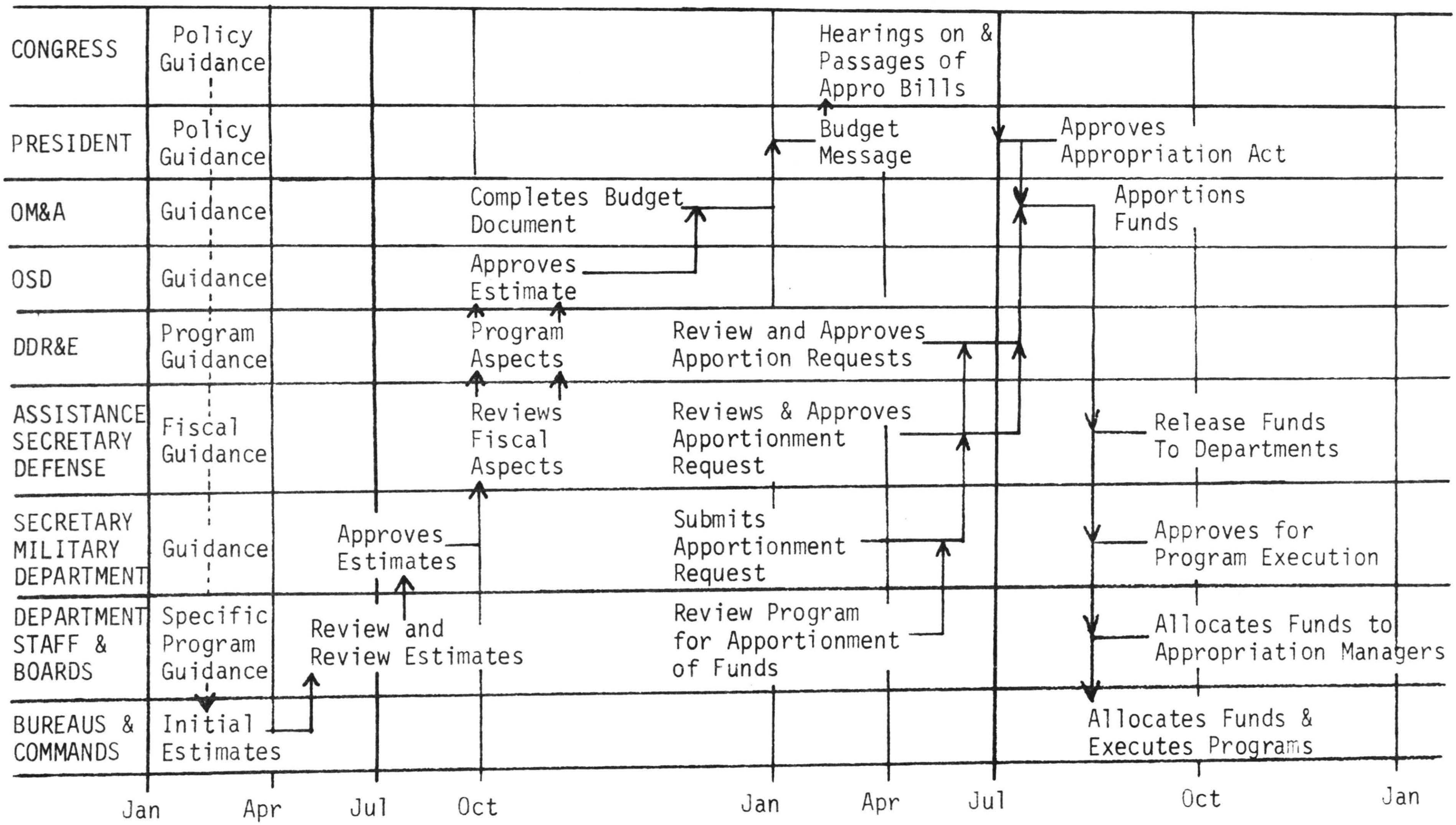


Figure 3. DOD Budget Cycle

departments. In turn, the DOD departments allot funds to subordinate elements of their individual programs. One of these elements that influences the Countersurveillance R&D programs is discussed below.

C. Army R/D Administration

1. Life Cycle Management

The ultimate objective of Army research and development is to develop weapons, equipment, and systems superior to those of any potential enemy, in any environment, and under all conditions of war. To accomplish this objective, the Army has established responsibilities, policy and general procedures for conducting research and development.

The principal management tool utilized by the Army in developing and fielding new items of equipment is the Life Cycle Management Model (LCMM) which is compatible with the Government's Planning-Programming-Budgeting System. LCMM illustrates and relates schematically the interrelationships of activities and events necessary for efficient material development. This model is divided into four phases--Acquisition Phase, Validation Phase, Full-Scale Development Phase, and Production and Deployment Phase. A complete description of each phase in LCMM and their ancillory activities is contained in DA Pamphlet 11-25.[3]

The typical material life cycle extends about thirty years from the time research is conducted to final disposal. This is not to say that the same system is in the Army inventory for thirty years before a new one is developed. In fact, a new item is usually developed and produced about every nine years. The time frames for the various phases vary greatly with the item or system concerned and depend primarily on timely completion of the development phase.

The key Army elements concerned with research and development and a brief description of their responsibilities are discussed below without regard to timing or phasing in LCMM. The Secretary of the Army is responsible for all affairs of the Department of the Army. To assist him he has an Under Secretary, three Assistant Secretaries, the Army Staff, and various other assistants.

a. Department of the Army Staff

1) Chief of Research and Development (CRD)--has Army General Staff responsibility for planning, programming, coordinating and supervising all DA research and development activities.

2) Deputy Chief of Staff for Military Operations (DCSOPS)--is responsible for the development of strategic concepts, estimates, plans, requirements, and issues guidance.

3) Deputy Chief of Staff or Logistics (DCSLOG)--is responsible for procurement, initial production facilities, production and distribution, and support from completion of production validation through disposal of the material.

4) Assistant Chief of Staff for Force Development (ACSFOR)--has responsibility for overall staff supervision and coordination for the life cycle evaluation of material to indicate the validation of material objectives and requirements, establishment of priorities, and operational tests and evaluation of material.

5) Assistant Chief of Staff for Intelligence (ACSI)--is responsible for technical intelligence, threat forecast, and activities in support of all aspects of the ARMY RDTE effort.

b. Major commands responsible for conducting research and development.

1) Army Material Command

2) Army Security Agency

3) The Surgeon General

4) Chief of Engineers

5) Strategic Communications Command

6) Air Defense Command

7) Training and Doctrine Command

2. Army Plans/Documents

The development of the future Army and its RDTE programs is based upon estimates of the future threats to the military security of the United States and approved plans to meet such threats. Army plans provide the broad framework of guidance within which the Army's research, combat development and material development activities are conducted. The DOD documents of greatest significance are Joint Long Range Estimates Intelligence Document, Joint Strategic Objectives Plan, Joint Research and Development Document, and Joint Strategic Capabilities Plan. These documents and the Five-Year Defense program give quidance to the development of Army plans. The Army plans, in turn, provide data and concepts to serve as the basis for Army inputs to succeeding generations of overall DOD plans.

The Army planning effort is based on a twenty year projection of its needs contained primarily in three planning documents--Army Analysis of Intelligence (AAI), Army Strategy Objective Plan (ASOP), and Army Strategic Capability Plan (ASCP). Each of these plans is arranged in a manner to cover the short-, mid-, and long-range period and reflect guidance contained in National and DOD policies. Threat forecasts, and joint plans. Specific research and development guidance is provided by the Army Long Range Technological Forecast (ALRTF). This forecast is prepared by the Army Material Command and describes the knowledge, capabilities, and materials which science and technology can be expected to produce if supported by research and development programs. The integration of the material resulting from RDTE programs into existing forces is addressed in the Army Force Development Plan (AFDP). Additional plans and guides are available for more specific guidance in various areas.

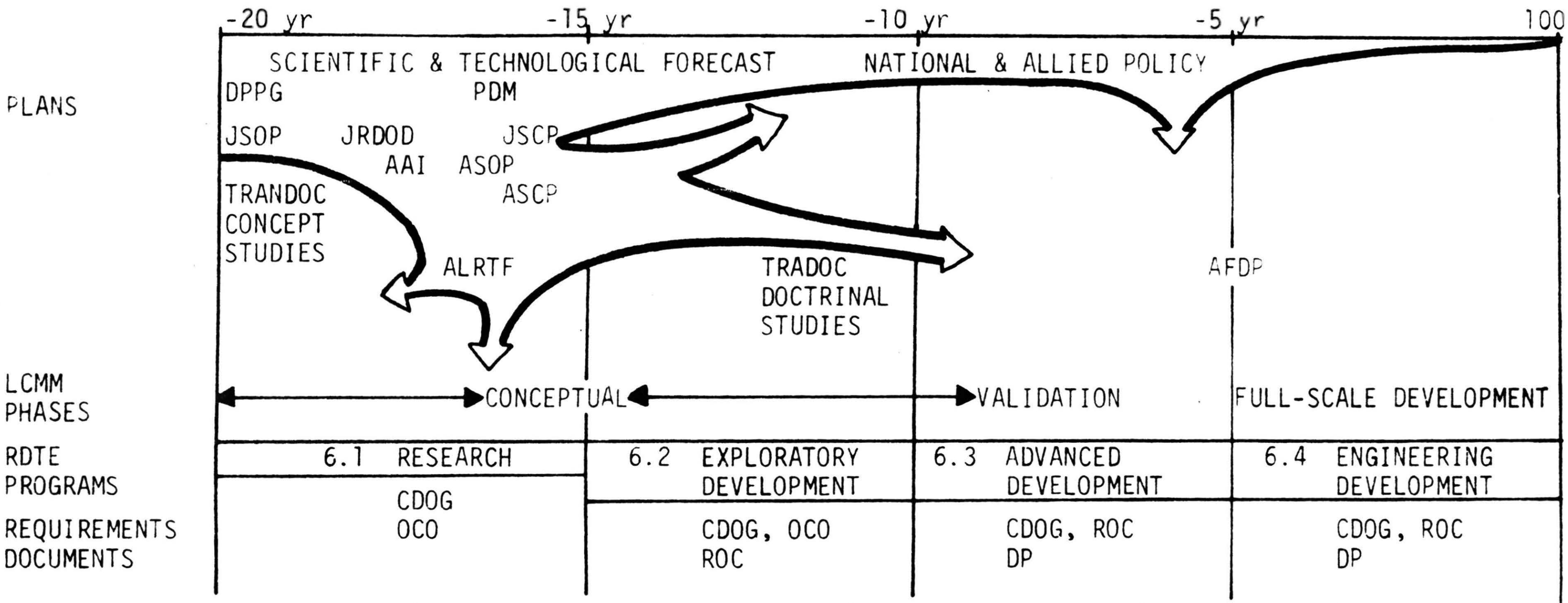
The Army's Material needs are stated as either objectives or requirements depending on how clearly the item of hardware can be envisioned. Each stated material objective or requirement may have one or more R&D projects or tasks that are responsive to it. To support work in the various RDTE programs requires approved material documents. The three main documents are: Operational Capability Objective (OCO), Required Operational Capability (ROC), and the Combat Development Objective Guide (CDOG). The OCO is a description of an operational capability desireable of achievement in a specified time frame ten or more years in the future. The ROC is a document which may originate with any element or individual in the Army when a potential threat is identified, technological opportunity appears, or when existing items approach obsolescence. CDOG provides guidance for the overall research program.

The interrelationships between R&D planning and documents previously described is shown in Figure 4. The plans and documents are arranged in their approximate relationship to the LCMM, with the left side of the chart representing the long-range planning effort. The cycle progresses to the right in time until the Initial Operational Capability (IOC) data is accomplished. R&D planning in the long-range period is oriented on acquisition of knowledge, while in the mid-range period it is directed toward development of material. Throughout the cycle there is a constant dialogue between the planning elements and developing agencies.

3. RDTE Programs/Progress Reporting

To control the various projects established in the Army, a project numbering system is utilized (Figure 5). This numbering system is applied to each Army project to identify it throughout the reporting system. The reporting system is made up of research and development, technical, and management information covering all projects and task areas. This reporting system provides a means for evaluating the relevancy of RDTE efforts to approved Army requirements and objectives, as well as, assessment of progress at the project and task area level.

The Research and Technology Work Unit Summary (DD Form 1498) is submitted to report technical and management information on the nature, scope, and future direction of the effort at the project and task level. Both summaries are usually prepared by the project scientist or engineer. Funding schedules and program data sheets (PDS) are submitted as part of the programming and budgeting process and provide



AAI - Army Analysis of Intelligence
AFDP - Army Force Development Plan
ALRTF - Army Long Range Technological Forecast
ASCP - Army Strategic Capabilities Plan
ASOP - Army Strategic Objectives Plan
CDOG - Combat Development Objective Guide
DP - Development Plan
DDPG - Defense Policy & Planning Guidance Memorandum
TOC - Initial Operational Capability

JRDOD - Joint Research & Development Objectives Document
JSCP - Joint Strategic Objective Document
JSOP - Joint Strategic Objective Plan
LCMM - Life Cycle Management Model
OCO - Operational Capability Objective
PDM - Program Decision Memorandum
ROC - Required Operational Capability
TRADOC - Training and Doctrine Command

Figure 4. Army Planning Interrelationships

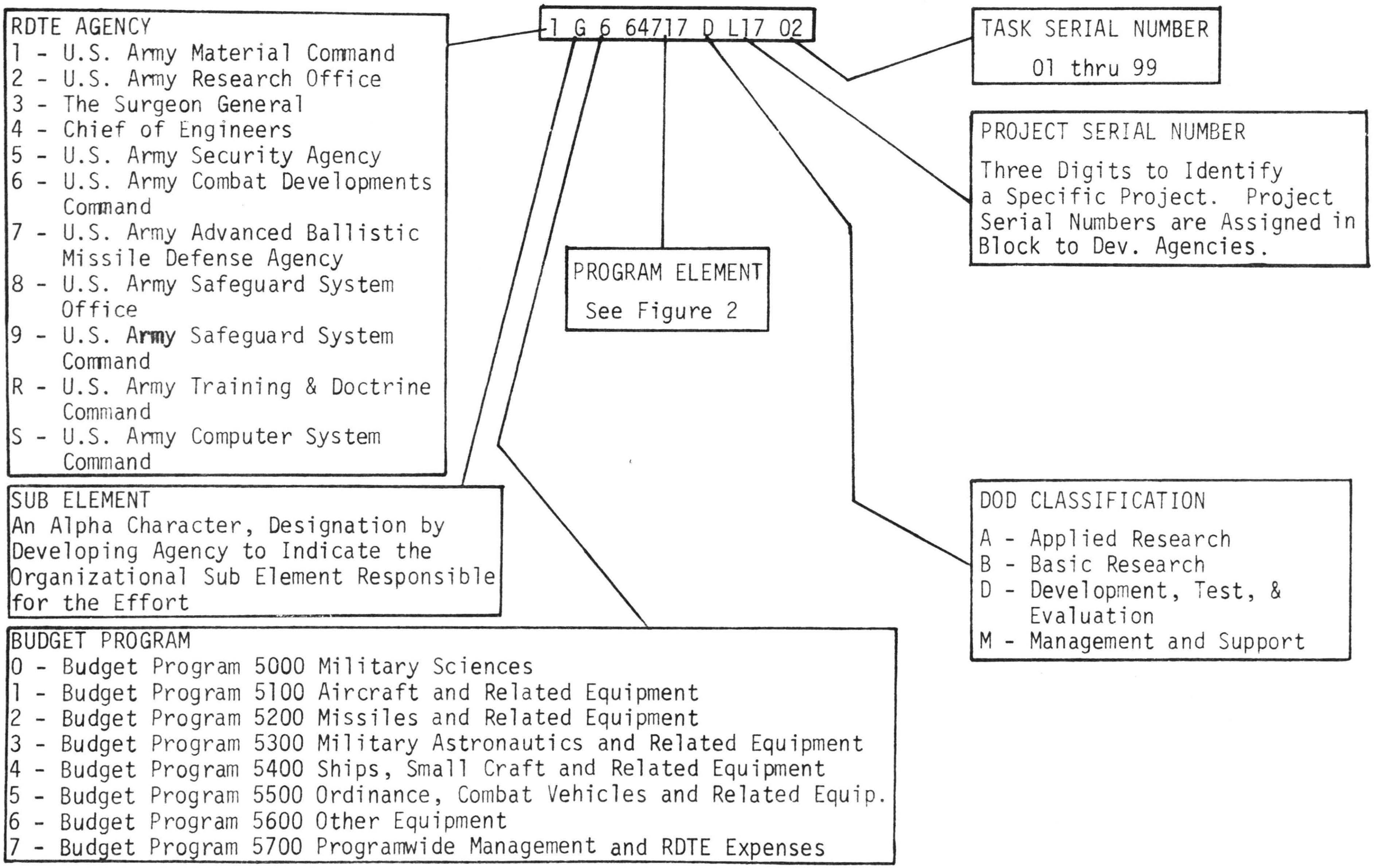


Figure 5. Army RDTE Project Numbering System

basic information for the Army Staff to review the RDTE Program and update the RDTE portion of the Five-Year Defense Program.

The previous discussion has briefly summarized the Government's and specifically the Army's R&D administrative procedures encompassing requirements documents, plans, programs, and reporting methods. The following section will identify the need for countersurveillance in the Army and will include the Countersurveillance and Topographic Division's mission and R&D programs.

III. INVESTIGATION OF REQUIREMENTS AND ACTIVITIES

A. Need for Countersurveillance

This section describes the surveillance threat as it pertains to the U.S. Army and identifies specific field requirements for Countersurveillance materials and equipment.

1. The Threat

As explained in the Army R&D Process, there must be a need for every item proposed for development. This need is established by interpretation and careful analysis of the enemy threat, along with our own Army user's requirement. However, it is not the function of the in-house research and development laboratories to become deeply involved in the analysis of the threat, but it is their function to be intimately aware of the threat in order to fulfill their mission in countering the threat.

There are two means by which objects are seen--by the energy they disperse and by the energy they radiate. All objects with temperature above absolute zero emit electromagentic radiation; the higher the temperature - the greater the intensity of radiation and the shorter the wavelength of maximum spectral radiancy. The total range of this energy is called the electro-magnetic spectrum and is illustrated in Figure 6. The energy waves in the various sections of the spectrum are fundamentally the same; they differ in wave length, in means by which they are produced, and in the effects produced when they are absorbed.[4(p. 484)] The principal energy bands employed in surveillance are ultra-violet, visual, near infrared, far infrared, radar or

WAVELENGTH		FREQUENCY (IN MC)
.03	ANGSTROMS	10^{14}
.3	ANGSTROMS	10^{13}
3	ANGSTROMS	10^{12}
30	ANGSTROMS	10^{11}
300	ANGSTROMS	10^{10}
0.3	MICRONS	10^{9}
3	MICRONS	10^{8}
30	MICRONS	10^{7}
300	MICRONS	10^{6}
0.3	CM	10^{5}
3	CM	10^{4}
30	CM	10^{3}
3	METERS	10^{2}
30	METERS	10
300	METERS	1

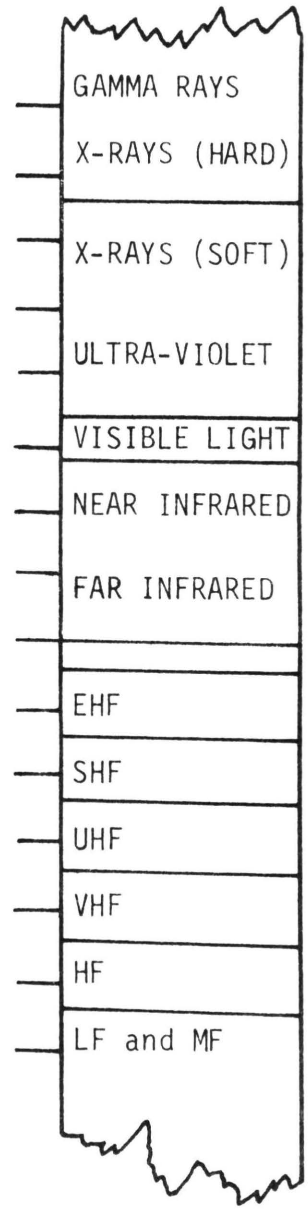


Figure 6. Electromagnetic Spectrum

a combination thereof. Surveillance sensors utilizing these energy bands can operate in space, in the air, or on the ground.

a. Ultra-Violet Range-The ultra-violet band is composed of energy of wavelengths shorter than visible light. The primary source for ultra-violet reflections from artificial and natural materials is solar radiation. However, most natural materials, soils, foliage, etc., have a very low reflectance. The same is true of conventional materials and paints with which military equipment is fabricated and coated. Also, ultra-violet energy is highly susceptible to attenuation by atmospheric scattering. This is particularly true of temperate and tropical climates where atmospheric moisture content is high.

Because snow is an excellent scatterer of ultra-violet radiation, the Artic, sub-Artic, and northern regions which experience sustained snow cover provide a high degree of target-background contrast in the ultra-violet spectral region. Measured values of reflectance range from a high of nearly one hundred percent for fresh, dry, fluffy snow to a low of about sixty percent for aged, crusted snow. Since atmospheric moisture content is normally low in frigid zones and artificial materials have a low reflectance, target-background contrasts are high and significant detection distances can be achieved.

The primary sensor means utilizing this spectral range is photography. However, direct viewing electro-optical devices are feasible.

b. Visual Range - Even with the increase in technological advances in sensor apparatuses, the most widely used method to detect a target is by the unaided eye. Some of the many reasons for this are: high equipment cost, unreliability of the equipment and operator, size and weight of the equipment, and probably most importantly, the lack of using existing countersurveillance material and measures in the field. The last reason is highlighted by a current evaluation of the status of camouflage in the field conducted on 17 March 1972 at Ft. Hood, Texas and is indicative of the state of camouflage army-wide.[5]

Due to the nature of the eye, its use is severly limited by the amount of light available, prevailing weather conditions, and the configuration of the terrain. To increase the range of the unaided eye under these adverse conditions, visible light sensors have been developed that operate in the visual band of the electromagentic spectrum. These devices include television, image intensifiers, and photography.

Television offers an unlimited range to which normal vision can be extended depending upon the camera, communication circuit, and viewing screen. Verification of this unlimited range was shown by the excellent television coverage of the recent Apollo moon expeditions. Depending upon the type of camera used, surveillance by television is possible by either day or night. Television surveillance is mainly used in a ground-to-ground or an air-to-ground role. Reception quality depends upon the type of camera used, stability of viewing platform, weather conditions, type of communication circuit, and receiver. The chief advantages of this sensor are real time intelligence, multi-viewing from one input source, and playback options.

Starlight scopes, night viewing binoculars, and weapon sights make use of electronic devices to increase the brightness of an image which is below the visual threshold to a level where it can be readily seen by the unaided eye. These light intensifiers are used mainly in a ground-to-ground function and their limiting factors are similar to the naked eye in that their effectiveness is affected by weather conditions, field of view, background contrast, and intensity of available light. The main advantages of these sensors are their detection range at night, passive nature in that they do not emit energy, and their ability to detect active near infrared devices. As stated earlier, television can also be used for night viewing. When combined with an intensifier image device, television pictures can be produced with only one hundredth the light required with a conventional camera tube.

Photography is probably the most useful remote sensor system because of its high degree of development, large number of known applications, and number of people trained in analysing the imagery obtained. Photography in the visual range includes color and black and white pictures. Black and white film, the most widely used in military aerial photography, records images in tone gradation of gray between white and black. On the other hand, color film provides color contrasts in addition to tonal contrasts. Because color film is slightly different in sensitivity than the eye, it often reveals camouflage by recording color differences not discernible to the unaided eye.

Both black and white and color film are available in a variety of types designed for low, medium, and high altitude reconnaisance. Photographs are normally taken during daylight hours but can be taken at night if electronic or pyrotechnic flashes are employed. Photographs are usually taken from the air in the vertical, high oblique, low oblique and panoramic positions depending on the view desired. The camera used may be equipped with a normal-angle lens, wide-angle lens, narrow-angle lens, or telephoto lens contingent upon the scale, ground coverage, and perception qualities required.

Results of photographs carried out in Gemini and unmanned observation satellites have shown vividly the applicability of this system in space. It has been stated that the high-resolution cameras used in the newest generation of observation satellites have a ground resolution of less than one foot from an altitude of 100 miles. These pictures in turn can be developed on the satellite and scanned by a television camera or laser system and transmitted to earth.[6(p. 14-25)]

Photography provides a permanent record, can be reproduced, contains millions of bits of measurable information, and can be studied for a prolonged time in various forms and by countless users. Its effectiveness depends on the film quality, camera lens system, altitude and stability of viewing platform, and the existing cloud cover.

c. Near Infrared Range - The near infrared band is composed of energy which has the same properties as light but is of longer wave lengths that are not detectable by the human eye. However, infrared film and infrared sensors are sensitive to these wave lengths, and the tones produced are the result of the degree of infrared reflectiveness of the object rather than its color. As a result, the value of the near infrared sensors lies in the fact that near infrared radiation and visible radiation are reflected and transmitted differently by objects. In darkness, near infrared sensors such as sniperscopes, periscopes, and tank searchlights, as well as infrared photographs utilize an artifical infrared source that is invisible to the unaided eye. However, this radiation source can be detected by infrared viewers and image intensifiers.

In daylight, near infrared film may be made by filtering out the visible wave lengths of light. Thus, surveillance by near infrared sensors presents a special problem for camouflage because living green vegetation reflects the infrared waves very readily and in great quantities in contrast with artificial green plants and materials, even though their colors are the same in the visible range. This phenomenon which holds true for other colors is exploited in photography. Infrared photographs may be taken in black or white or in color (camouflage detection film). The camouflage detection film is so made as to reproduce an image of living plant life as red and other images are recorded as some other color, usually purple or dull blue. Because of this high contrast, military targets are more easily detected. Infrared photographs taken from long distances or from high altitudes show improved clarity of detail because the atmosphere may selectively transmit the near infrared bands and because the contrast of ground objects may be higher as a result of their different reflectivities in the near infrared regions.

d. Far Infrared Range - The far infrared band is similar to the near infrared band except the sensor detects the objects by their emitted radiations (heat). During daylight hours, surfaces with a high absorbance for radiant energy store up large amounts of heat, while surfaces having a high reflectivity absorb little heat. Therefore, most of the infrared radiation received in daylight is predominantly reflected radiation while at night it is emitted energy.

The range of infrared detection depends on the temperature and emission properties of the target as compared to its background, the atmosphere, the detector, and the electronic system used to amplify and display the signal. Air-to-ground surveillance devices utilize the infrared line scan and thermal mapping techniques. In the ground-to-ground reconnaisance role a technique known as thermal plotting is employed in which hot spots are indicated but no picture is produced. Since thermal radiation has a great penetrating power, due to its long wave lengths, it is possible to detect hot objects through a limited amount of cover and dust or haze, but not fog or clouds. Although thermal sensors can be used by night or by day, darkness offers the best conditions of thermal contrasts due to the absence of solar radiation.

e. Radar Range - Radar detection of an object is accomplished by transmitting a beam of microwave frequency energy and detecting the energy reflected by the object. The three general types of radar systems are continuous wave, pulsed, and frequency-modulated. Pulse radar systems are based on measuring the time it takes a short burst of energy to travel to and from the target. Continuous wave radars transmit continuously and operates on the detectable change in frequency of the reflected wave from a moving target. Due to its continuous transmission, continuous wave radars have the ability to measure velocity but not range. In ground-to-ground surveillance, pulse doppler radars are normally utilized to measure the range of moving targets. In the air-to-ground role, side looking airborne radar (SLAR) is utilized in the "fixed target indication" or "moving target indication" modes. In the fixed target indicator (FTI) mode photograph pictures of terrain, seacoast, clouds, etc., can be produced, but with poor definition. In the other mode, moving targets appear as bright echoes, while ground clutter is suppressed.

Radars can operate either passively or actively. Passive radar systems employ only the reception of microwave-frequency energy and have the ability to discriminate between different targets and backgrounds better than either active radar or infrared systems. Radar's inherent advantages over other detection systems are: it has greater range; it is usable day or night and in any weather condition except heavy rain; and its electronic components are highly developed.

f. Multiband Spectral Range - Multi-spectral surveillance instruments utilizing different regions of the electromagnetic spectrum simultaneously increased the spectral resolution of the target over conventional sensor systems. The property of an object or material to selectively reflect certain components of incident energy and to absorb or transmit the remainder is termed spectral reflections. When the spectral reflectance properties of an object and its background are known, the sensor sensitivity may be adjusted to be more responsive to these regions. This fact is made use of by recording the object simultaneously with multiple sensors with different sensitivities in selected narrow band widths. Hence, the problems relating to effective countersurveillance become much more complex when multi-spectral sensor systems are employed.

g. Anti-Intrusion Sensors - In order to provide surveillance in areas that cannot be covered by the sensors discussed so far due to their limited line-of-sight or limited frequency of observation, a system of remote sensors have been developed that do not rely solely on the electromagnetic spectrum. These sensors detect enemy vehicles and personnel either seismically, acoustically, or magnetically and relay the information to a control or monitoring station. Acoustical devices detect noise or other vibration set up in the air while seismic detection systems record earth vibrations such as footsteps. In similar fashion, magnetic devices detect any change in the surrounding electromagnetic field caused by ferro-magnetic materials. Also included are infrared and balanced pressure detectors. Detection by these devices consists of an intruder breaking an invisible infrared beam or the pressure applied by the intruder when he passes over one of the pressure bases.

2. User Requirements

Requirements for new methods, materials, and techniques in countersurveillance has increased rapidly in magnitude due to new technological advances in surveillance systems, recent demands from Viet Nam, and current assessment of U.S. aerial superiority in future conflicts. These factors have generated a military need to enhance the ability of the Army to degrade the capabilities of existing and future reconnaisance, surveillance, and intelligence systems. In this regard, it has been recognized that countersurveillance programs offer one of the greatest potential returns in terms of preservation of force versus resources committed.

Regardless of the type of observation employed, there are certain fundamental physical characteristics of targets which help to determine their detectability and identification. These factors of recognition are: position, shape, shadow, texture, color, movement, and spectral reflectance. A thorough explanation of these factors and the principles of camouflage such as choice of position, camouflage discipline, camouflage construction, etc., are contained in the department of the Army Field Manual 5-20.[7]

An interrelationship exists between the factors of recognition and the environment in which the object is displayed. Many things contribute to the overall character of an environment. For example, geographic factors contribute throughout the textural scale, from topographic conditions such as mountains, valleys, river; to vegetation changes due to the different seasons and different types of terrain, i.e., desert, temperate, tropic, etc. Meteorological conditions also contribute to the character of the environment. Rain, fog, cloudiness, heat, sunshine, ice, and snow all have their unique effects on the environment and in turn on the various surveillance systems.

Training of combat units in countersurveillance doctrine is accomplished by the United States Army Training and Doctrine Command through its branch schools located throughout the United States. A list of the various training manuals, films, and other publications that are utilized by these schools in camouflage instruction is provided in Appendix B. It is felt that an important insight into existing user needs in camouflage materials and techniques can be gained by a review of this literature. However, in order to furnish a clearer understanding of the military R&D problem areas for those that are not intimately familiar with the data given in Appendix B and/or acquainted with existing development tasks; several aspects of field camouflage will be described.

a. Personnel - Activities of individuals can be viewed by observers in the air or on the ground. It can be expected that the enemy will use visual sensors, such as, image intensifiers, binoculars, anti-intrusion devices, near infrared photography, and moving target indicator radar systems. Although concealment of the individual depends largely on choice of position and good camouflage discipline in reducing the factors of recognition, the individual camouflage effectiveness can be greatly enhanced by materials that will reduce his contrast with that of the background. Some of these material requirements are: clothing which blends in with the predominant color and pattern of the background and can be altered to blend with the change in seasons; facial paints to tone down the skin; bands and covers to eliminate the characteristic shape and contrast of the helmet and other personal gear; films that reduce the glare from eyeglasses; unit and commander markings that cannot be seen except at very close range; and personnel camouflage nets that are effective against visible and infrared sensors.

b. Equipment - Sensors can be used most effectively against the majority of Army equipment due to their specific operational and physical characteristics. Because large amounts of energy are capable of being emitted or reflected, the infrared and radar sensors systems are employed more extensively against equipment than personnel. As with personnel, correct camouflage discipline, change of position, and other camouflage methods reduce the expenctancy of detection. However, with the advent of sophisticated sensor devices operating throughout the entire electromagnetic, acoustic, and other spectrums, the probability of discovery and identification of individual types of equipment is quite high.

Camouflage requirements for the immediate time frame are addressed to specific items or classes of equipment while long range goals emphasize the "built-in" concept, i.e., incorporation of camouflage features into the basic equipment designs. Various materials and measures that can be applied to several classes of equipment and their utilizations are as follows:

Paint--A white pigment formulation with ultra-violet reflectance of 75% and easily removable is required for items susceptible to snow conditions.

Colorants--Improved camouflage green colorants for paints and coatings are essential to ensure camouflage effectiveness against spectrozonal photography.

Pigments--Chromotropic pigments and organic colorants suitable for development into paints and coatings which can be induced to change color under the influence of ambient or applied energy fields.

Disruptors--Materials are required that disguise the item as part of the natural or habitated environment, but do not reduce its operational capabilities.

Portable Spectral Material--Containerized material and rapid dispensing systems are required for production of disposable camouflage material in the field. This material should posses a broad spectral response for concealment primarily against visual and near-infrared surveillance devices.

Lightweight Screening System--Synthetic Camouflage materials that reduces the weight, cubage, water absorption, maintenance requirements, with improved near-infrared reflectance characteristics, and conceals against radar detection are required for three different type terrains with corresponding seasonal variations. These screens will be utilized in concealing active radars, as well as,items from radars.

In addition to the above, specific material and measures are required to reduce the individual signature of selected items such as vehicles, aircraft, weapon systems, field installations and fortifications. Vehicles, generators, and other major heat-producing items require thermal dissipating materials to reduce their vulnerability to infrared sensors. Materials or new designs are needed to eliminate characteristic shadows such as in the area of the suspension and between the cab and frame. Physical optical coatings or canopies that eliminate the specular reflectance of glass windows or other smooth aerodynamic surfaces can be utilized on aircraft and vehicles. In order to reduce the contrast of aircraft such as helicopters on open ground, a means of making helicopters mobile on the ground is essential to their concealment and dispersion. New techniques or mechanisms are needed to reduce the flash, smoke, dust, and stereotyped layout of weapon systems such as the Hawk Air Defense System. To negate advancing multispectral surveillance and target acquisition treats to mobile and semi-employed military items a lightweight, camouflage canopy system with broad spectral (visual/near infrared/far infrared/radar) characteristics that can be quickly assembled and dismantled is desired.

Proper site selection is probably the most important consideration in planning field fortifications and installations. Primary surveillance will likely be high altitude photography in the visual band and infrared/radar photography at lower levels. Due to the large concentration of supplies, vehicles, and other military essentials that are constantly moving forward, requirements exist for integral support systems that are simple to operate and capable of supporting single and multiple synthetic camouflage screen assemblies in configurations to obtain installations clear of poles, ropes, or other supporting materials.

Even if the enemy knows the exact locations, camouflage materials and techniques will offer considerable protection from all forms of attack which rely on visual acquisition of targets. Some of these visual/photographic materials and uses are: tone-down paints for collapsible fuel storage tanks and other large semi-permanent items that blends the hardware with existing patterns; stabilized soil colorants for camouflage of scarred earth; and texturing materials for roadway surfaces.

c. Deception - Countersurveillance activities consist of both concealment and deception operations. Concealment activities include those actions and materials taken to hide or disguise men and equipment as discussed earlier. Deceptive activities are designed to mislead the enemy information-collection systems by manipulation, distortion, or falsification of evidence to induce him to react in a manner prejudicial to his interest. Therefore, the target of the deception operation is the enemy command element that exercises control and makes decisions.

The degree of exactness with which the characteristics of archetype items must be duplicated in the simulation device is dictated by the resolution and spectral sensitivity of the enemy's sensor system. Decoys that are employed in the visual-photographic region require replication of shape, and surface features approximately on a one-to-one basis because of the minute detail resolable by the optically aided eye and photographic system. However, with increasing wave length through the thermal infrared and microwave spectrums, sensor resolution falls off rapidly and simulator fidelity requirements decrease accordingly. Decoys designed specifically for these spectral regions need not have visual fidelity; however, they do require modular construction to permit true spatial representation of archetype signatures. Also required, in the case of thermal simulators, are programmable radiation levels to compensate for environmental variations. In addition, acoustic fidelity is needed to simulate tank movements, rifle fire, and other battlefield sounds.

Sometimes it is as important to prolong the time it takes the enemy to analyze information supplied by his information-collection system, as it is to deny the information to him completely. This weakness can be exploited by deliberately increasing one's activities in order to generate more data and overload the enemy's intelligence system. This can be accomplished by flooding the enemy with misleading, real, and deceptive information.

B. Countersurveillance Activities at the Laboratory Level

The following topics describe the mission and programs of the Countersurveillance and Topographic Division. The specific technical and administrative responsibilities are outlined in order to emphasize the managerial requirements necessary to execute a R&D program of this complexity. The technical programs and tasks that are given have a direct relationship to the threat and user requirements that were analyzed in the previous section and provides one with an overview of the particular scientific knowledge that is utilized, as well as, the state of the art in countersurveillance.

1. Mission

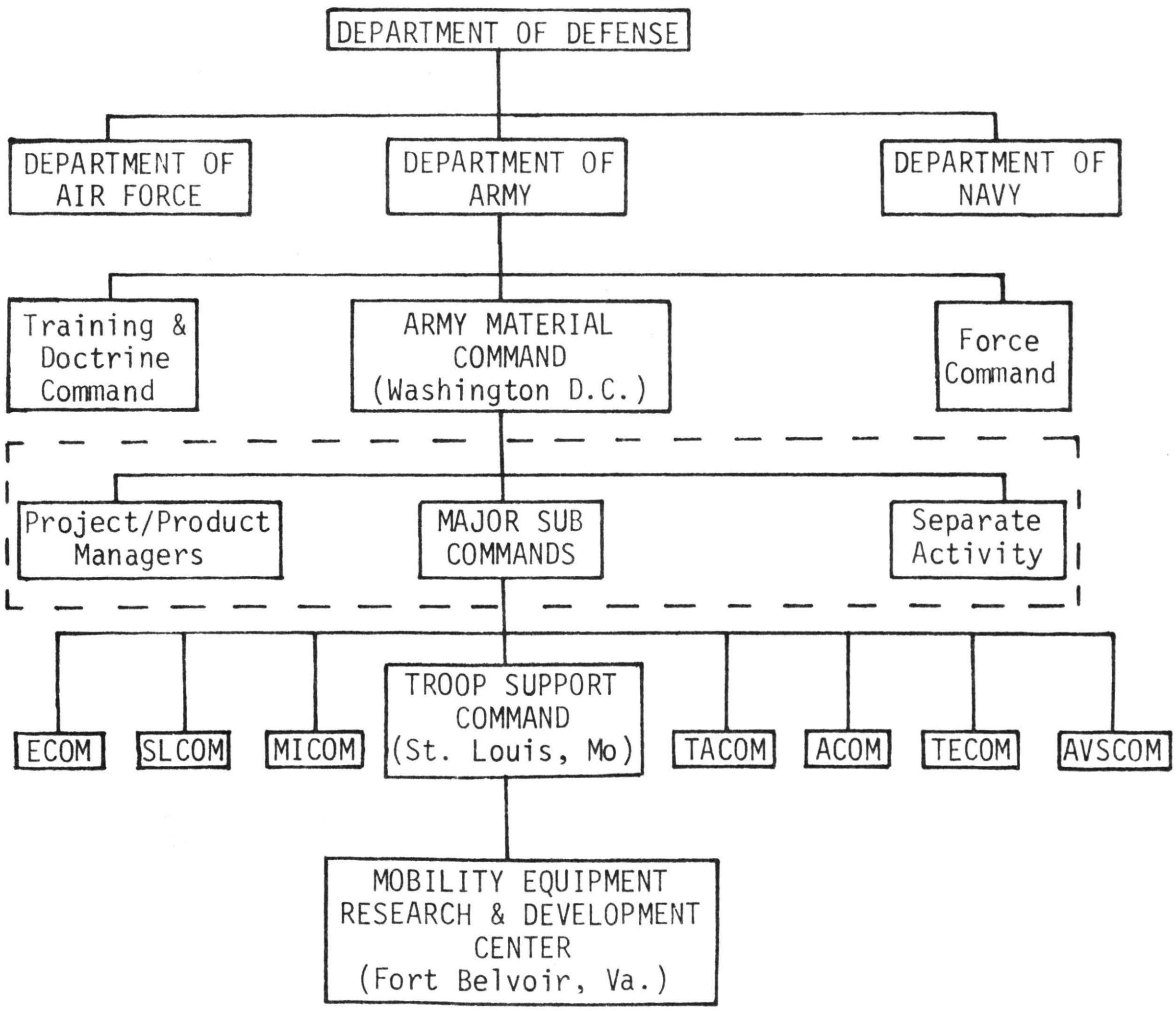
The U.S. Army Material Command (AMC) is responsible for conducting camouflage research, development, testing and evaluation of materials, systems, and techniques required by the Department of the Army. In this regard, AMC has prescribed specific policies and responsibilities concerning camouflage to major subordinate commands; project/product managers; and separate installations and activities reporting directly to AMC. Within AMC Headquarters, the Director of Research, Development and Engineering has overall staff supervision and coordination for the implementation of this program. Day-to-day staff supervision review, evaluation, and coordination is further designated to the General Support Equipment Branch of the Surface Systems Division.

Countersurveillance activities include all measures taken to prevent surveillance and is made up of two types; ACTIVE measures which interfer or otherwise render ineffective remote sensing means or its transport, and PASSIVE measures which are concerned with the with the treatment of objects to prevent detection or deny proper identification and location, as well as, to provide false signals to confuse and deceive. Camouflage activities include taking advantage of the natural environment, as well as, the application of natural and artifical materials to minimize the probability of detection. The camouflage program presented is primarily designed to increase the Army's capabilities in the passive areas. Therefore the terms camouflage and countersurveillance as used in this thesis are interchangeable in that they are the application of passive measures and characteristics of material contributing to the reduction of perceptibility to surveillance. Perceptibility is the characteristic, state, or quality of an item which causes it to be subject to detection, identification, and/or location by surveillance means.

The main mission of the AMC camouflage program is to reduce the perceptability of Army material to detection, location, and identification. The specific responsibilities assigned to the various elements within AMC in carrying out this mission is contained in AMC Regulation No. 70-58.[8] One of these AMC elements, the Mobility Equipment Research and Development Center (MERDC) has been designated the AMC Lead Laboratory for Camouflage Technology. MERDC's organization relationship with the DOD command structure is shown in Figure 7. MERDC's responsibilities in camouflage RDTE includes:

Determining the vulnerability of Army material to detection, location, and identification by known and anticipated surveillance and target acquisition sensors.

Conducting studies and analysis to evaluate the effects of these vulnerabilities throughout the material items or systems life cycle.



ECOM - Electronics Command

SLCOM - Safeguard Logistic Command

MICOM - Missile Command

TACOM - Tank & Automotive Command

ACOM - Armaments Command

TECOM - Test & Evaluation Command

AVSCOM - Aviation System Command

This block has been added to emphasize that various elements report to Army Material Command

Figure 7. Chain of Command

Furnishing the results with appropriate recommendations to the responsible major subordinate command, project manager, activity, and to AMC.

Recommending material concepts and measures to reduce the camouflage perceptibility of Army material.

Participating in RDTE testing with the responsible development agency or test command by providing technical advice concerning levels of camouflage needed to counter existing threats.

Develop, manage and maintain the camouflage technology base.

Design, develop, and incorporate into items and systems the necessary countersurveillance material to meet Army requirement documents.

Within MERDC, the countersurveillance and topographic division has prime responsibility in conducting and supervising all camouflage RDTE activities. These efforts include camouflage against all militarily significant approaches to remote sensing; in particular, the electromagnetic spectrum from ultra-violet through radar wave lengths. In performing this mission, the countersurveillance and topographic division is primarily responsible for:

Formulating a camouflage technology program encompassing research (6.1), exploratory development (6.2), advance development (6.3), and engineering development (6.4) RDTE efforts. These programs consist of inputs from all qualified elements of AMC together with recommended priorities. Upon approval, funds are distributed and surveillance and review procedures are implemented.

Summary reports on the technical progress, budget, design evaluations, risks, etc. of these programs.

Advising and assisting major subordinate commands, project managers, and other activities as required on camouflage technology.

Developing and maintaining, through appropriate intelligence agencies an awareness of the threat and associated equipment that may be encountered by the field army.

Maintaining liaison with the U.S. Navy, U.S. Air Force, and friendly foreign governments on appropriate programs.

2. Programs

The Countersurveillance and Topographic Division's RDTE programs are based upon an analysis of what must be done (Approved Objectives and Requirements), guidelines to be followed (Life Cycle Management Model), relative priorities of objectives (Army RDTE Project Listings), who will accomplish the objectives (In-house, Industry, Government Agency), and resource requirements to support these objectives (Army Five Year Force and Financial Plan). Past camouflage efforts have been aimed at gaining an understanding of the complex relationships involved and to providing answers to specific material problems. However, this effort has been extremely modest in comparison to the development of sensor systems. The present Countersurveillance Program is directed at reducing the perceptibility of Army material by completing existing equipment development tasks, providing support to AMC sub-commands, initiating the "bulit-in" concept, and developing the tools, information and novel concepts and materials needed to provide practical solutions to future needs and requirements.

The program consists of four areas: three in research and development and one in Procurement of Equipment and Missiles, Army (PEMA) and Operations and Maintenance Army (OMA). These areas are discussed below in order to provide a general comprehension of the nature of the problems, organizations that are involved, resources that are needed, and management procedures that are required.

a. Program Area I (Camouflage Technology) - The objective of this program is to provide the Army with a continually updated technological material capability in the field of countersurveillance. This program is broken into four task areas as follows.

Task 01 - Camouflage Measurements and Classification. The goal is to develop the scientific methodology needed to analyze and define the countersurveillance (CS) problem in engineering terms and to measure the effectiveness of the countersurveillance solutions. The problem is broken into four parts: development of a measurement system for definitive specifications of technical requirements and quantitative assessment of material solutions; development of a computer-aided methodology for a rapid design reaction capability and to define permissible performance characteristics; development of a standardized computation system for determining the cost effectiveness of CS systems; and development of quality assurance instrumentation for measuring characteristics of material in meeting CS requirements.

A contract with industry has produced a basic computer model SCREEN into which signature/background relationships are programmed to define the degrees of countersurveillance (CS) effectiveness. Debugging is being accomplished in-house in conjunction with the System Engineering and Computation Support Office CS System Study. Calibration and evaluation in the field have been coordinated with Night Vision Laboratory (Ft. Belvoir), Army Material System Analysis Agency (Aberdeen Proving Ground), Combat Developments Command Engineer Center (Fort Ord), Modern Army Selected Systems Test Evaluation and Review (Fort Hood), and the United States Air Force and the North Atlantic Treaty Organization (NATO) proposed Joint Field Trials. Contracts will be awarded to industry for refinement of the SCREEN computer model and to develop specific quality assurance instruments. Efforts will continue on the Photo Match computer model which calculates the color sensitivity variance envelope for color photographs. Field tests will be conducted in cooperation with Night Vision Laboratory (NVL) to pin-point CS problem areas as related to modern sensors.

Task 02 - Camouflage Materials and Measures. The objective of this task is to devise and produce new and novel material concepts and techniques for CS systems to provide U.S. Forces with a continually updated concealment and deception capability against enemy surveillance and target acquisition systems employing electromagnetic and/or acoustic sensors. Research and exploratory development are being conducted to establish the necessary technological base for analyzing intelligence threats and generating new material concepts and use techniques. This endeavor is split into two fundamental areas of CS technology: camouflage and simulation.

Contracts were awarded to commercial companies to develop a universal infrared camouflage canopy system; to conduct infrared signature analysis of military equipment components; to carry out radar ground plane and target signature analysis utilizing an existing microscopic radar imaging facility; and to study methods of reducing glint, glare, and noise from helicopter rotar blades. Inputs from these activities are being provided to AMC subcommands. In house work includes improving existing paints, coatings, and pigments for ultra-violet reflectant snow paint and white polymeric coatings for rubber and fabrics. Studies will be performed on radar scattering mechanisms, holographic projection of 3-dimensional images, and integrated countersurveillance systems. In-house efforts also will continue in the development of a computer program, color match, that automatically formulates colorants to meet prescribed spectral requirements. Equipment to be procured includes microwave field measurement instruments, microwave transmissometer/reflectometer, infrared imaging radiometer, and portable total emissometer.

Task 03 - Criteria for Camouflage in Equipment Design. The aim in this area is to collect and codify information on target signatures, world backgrounds and environments, and surveillance sensor capabilities for use in countersurveillance (CS) computer programs; exchange camouflage information and develop standardization agreements with foreign nations through visits and annual meetings; participate in NATO R&D programs in CS; investigate new camouflage concepts from industry and the scientific community via visits and periodic symposiums; conduct evaluations of commercial camouflage products both foreign and domestic; and produce Technical Handbooks on CS for use by commodity developers.

In support of various camouflage R&D goals, representation is being maintained on various national and international panels such as: Army Commanders Conference on Tactical Cover and Deception, AMC Ground

Target Signature Study, NATO Panel AC/243, and the Military Agency for Standardization (MAS) working party for CS. Assistance in CS is provided to DOD agencies upon request. Formal agreements have been actively maintained with foreign countries on background data, CS materials, and new camouflage requirements. A coordinated program has developed with several NATO countries to conduct a joint field study of assessing passive CS devices and techniques. Information exchange between the military, scientific and industrial community on CS are being conducted through R&D symposiums. Computerized data storage and retrieval system for information pertaining to CS are being explored with in-house computer and analysis personnel.

Task 04 - International Developments. The purpose of this task is to exchange camouflage information with foreign nationals through Data Exchange Annexes (DEA), visits, annual meetings, participation in NATO R&D CS programs, conducting tests and evaluations of foreign and domestic camouflage equipment, and through standardization agreements with foreign countries.

Efforts through fiscal year 73 are covered by Task 03. Future efforts will be primarily concerned with NATO field tests and membership on international panels such as NATO panel AC-243, SG/RSG-1, and MAS Working Party on Camouflage and Concealment. Memorandums of Understanding, data exchange agreements, and evaluation of CS materials and techniques will continue.

b. Program Area II (Camouflage Advance Development).- The object of this program is to upgrade the Army's battlefield survivability through camouflage technology by reducing the perceptibility of Army material through passive measures of hiding, blending, disguise, and simulation. This program involves identification of critical problem areas in CS throughout AMC Commands and Laboratories, development of prototype camouflage and simulation systems, and evaluation of these materials and techniques through realistic field demonstrations.

Task 01 - Joint AMC Countersurveillance Advanced Development. The aim of this task is to formulate a Camouflage Technology Program in specific terms that apply to designated material and equipment under the purview of all AMC commodity commands. A viable program is being developed with each subcommand to integrate as much of the built-in camouflage concept as possible, keeping special solutions to a minimum.

Meetings and coordination has been accomplished with representatives of all AMC commands to establish the critical problem areas in countersurveillance (CS) and finalize programs that offer promising solutions. Funds have been supplied for the support for these programs, as well as, specialized schooling in order to initiate total AMC involvement. AMC elements that are included in this program are: Tank Automotive Command, Missile Command, Electronics Command, Armaments Command, Aviation System Command, and the Troop Support Command. Some of the on going projects and organization include:

1) Ballistic Research Laboratory - incoroporate a digital computer model of camouflage netting compatable with and for use in the Ground Target Signature Modeling Program:

2) Human Engineering Laboratory - investigation of the effectiveness of the color blind eye to detect camouflage targets, development of laboratory procedure for assessing new camouflage

techniques based on pattern perception;

3) Cold Regions Research and Engineering Laboratory - measurements of the spectrual reflectance of snow to determine a data base for designing camouflage materials;

4) Electronic Warfare Laboratory - to develop radar absorptive continuous monofilaments of threads for camouflage materials;

5) Night Vision Laboratories - evaluation of camouflage technology through digital imaging processing;

6) Tank-Automotive Command Laboratories - a study of methods that utilize ambient air or engine fan air to cool exhaust gases prior to expelling them, determination of the sources of track and suspension system noise and means of altering that noise signature;

7) Picatinny Arsenal - heating of inflatable decoys to avoid detection by thermal devices;

8) Natick Laboratories - to investigate camouflage techniques for packaging, shipping containers, and packing materials;

9) Missile Electronic Warfare Technical Agency - to determine the susceptability and vulnerability of the Honest John Missile to detection, recognition, and destruction.

10) Land Warfare Laboratory - investigate the feasibility of developing a camouflage type paint that will change color by some physical phenomenon, a study to determine materials that could be utilized for an instantaneous camouflage of vehicles, to improve an existing camouflage reflective shield system.

Specialized, but mutually complimentary sub-tasks will immediately be applied to the problem area, followed by prototype development of solutions. These sub-tasks are: glare reduction, broadband camouflage system, helicopter decoys, helicopter landing pad camouflage, signature simulators, camouflage screen support system, and support for Modern Army Selected Systems Test Evaluation and Review (MASSTER).

Task 03 - Demonstration and Evaluation of Camouflage Equipment and Concepts. The goal of this task is to provide support for the demonstration and evaluation of camouflage materials and equipment in a real life operating environment. From such demonstrations and evaluations, operating experience can be gained which determines requirements, modifications, concepts, and uses of camouflage equipment forming a logical basis for the direction of research, development and engineering activities.

Modern Army Selected Systems Test Evaluation and Review activities are considered typical of this type of demonstration/evaluation effort. Examples of some of the camouflage equipment that would be subject to this effort are as follows: screening systems, terrain reflectors, glare reducers, paints, patterning uniforms, dust suppressors, ground mobilizers, decoys, disruptors, and hydro-grassing.

c. Program Area III(Camouflage Engineering Development) - The objective of this program is to type classify for troop use, countersurveillance items and systems. Following prototpye demonstration, required items of CS material or systems are developed and submitted to the Test and Evaluation Command (TECOM) for final testing; upon successful passage of such tests, the CS item or system are proposed for type classification. These engineering activities are characterized by the bulk of the Technical effort being performed by industry while management reviews and analyses are conducted mainly in-house.

Task 01 - Simulating Devices. The aim of this task is to type classify for field use a system of high fidelity replicas of archetype military equipment that can be produced cheaply in large quantities. In-house efforts will include review of domestic and foreign equipment, molding and fabrication methods, laboratory experimentation and tests, and technical administration of contracts.

Task 02 - Synthetic Camouflage Screening System. This task is to complete engineering design and development of the U.S. version of a Lightweight Synthetic Camouflage Net or Screen System to replace current standard burlap-garnished cotton twine netting. Contracts are being awarded to industry for the development and production of test items for delivery to Test and Evaluation Command.

Task 03 - Camouflage for HAWK Air Defense Guided Missile System. Camouflage materials are required that will prevent detection and recognition of the HAWK system during transportation and when located at an operational site. This program is being accomplished on a coordinated basis with the Missile Command. Funds have been supplied to Night Vision Laboratory, as well as, civilian contractors to develop a baseline and a comprehensive program plan for integrating individual signature suppression systems into a composite system and evaluating the prototypes.

Task 04 - Broadband scattering and Suppression System. The aim is to type classify for field use a system of light weight broad spectrum (ultra-violet, visual, photographic, infrared, radar) camouflage disruptors for application to mobile and semi-emplaced military items. In-house efforts include determining engineering design specifications, writing the contract requirements, technical monitoring the contractual efforts, and coordination with Test and Evaluation Command on field testing.

Task 05 - Glare Control of High Luster Surfaces. The purpose of this effort is to type classify a system to eliminate or reduce glare from high luster optical surfaces. Selected material concepts and experimental models developed under exploratory development and advanced development programs are being used to determine the requisite design for engineering development, and will be modified as required for type classification.

Task 06 - Signature Simulation. This task is to type classify a modular system of signal generators which can be programmed to produce signatures for the simulation of military targets primarily in the thermal and microwave spectral regions, and secondarily in the acoustical spectrum. This program is being coordinated with Countermine/Counter Intrusion Department, MERDC, and Night Vision Laboratory to ensure fidelity requirements are met and to expand potential field applications.

d. Program Area IV (Procurement of Equipment and Missiles, Army and Operations and Maintenance Army) - The objective of this program is to provide engineering support to existing and development items in the countersurveillance field. A review of existing CS specifications is being accomplished to establish where revisions are required and where type classification (TC) action should be taken to remove outdated and obsolete equipment. Revision, review, and updating of specifications and set listing are being handled on an as-required basis. Type classification action will be taken to reclassify existing material. Preproduction test requiring travel to supplier's plants has been accomplished as required to support the Troop Support Command purchases. Support of Manufacturing Methods and Technology projects is accomplished by providing evaluation support for contractors proposals, evaluation of performance, and final contract review. Advanced production Engineering projects are undertaken on hardware items to provide an adequate technical data package and assure competitive procurement.

Funding for programs I through IV and their specific tasks is shown in Table I. It should be noted that an item has been added (CUSTOMER) to take care of other work efforts that fall outside the programs discussed above. Examples of this endeavor would be solving vulnerability problems for the Air Force or disguizing Remotely Monitored Battlefield Sensor Systems (RMBASS).

Table I. RDTE Program Funding

	PROJECT DESCRIPTION	FUNDING (thsds)* FY73	FY74	FY75
I.	CAMOUFLAGE TECHNOLOGY (1G662708DJ17)	1100	1000	944
	01 Measurement & Classification	388	250	244
	02 Materials & Measure	236	310	300
	03 Criteria for Camouflage	476	115	200
	04 International Development	-	325	200
II.	CAMOUFLAGE ADVANCE DEVELOPMENT (1G663702D471)	3550	4500	2306
	01 Joint AMC CS Adv Development	1900	2900	1175
	02 Prototype CS Adv Development	1650	1400	981
	03 Demo & Eval of Cam Equip & Concepts	-	200	150
III.	CAMOUFLAGE ENGINEERING DEVELOPMENT (1G664717DL17)	910	1570	2116
	01 Simulating devices	180	490	550
	02 Synthetic cam screen system	420	100	100
	03 Camouflage for HAWK	310	400	500
	04 Broadband Scattering & Suppression	-	200	250
	05 Glare of High Luster Surfaces	-	-	200
	06 Signature Simulation	-	380	516
	RDT&E Totals	5560	7070	5366
IV.	PEMA & OMA	380	280	280
	**CUSTOMER	350	400	250
	Fiscal Year (FY) Totals	6290	7750	5896

* These funding figures are approximate

** Activities not covered in above programs

IV. DISCUSSION OF FUTURE MANAGEMENT CONCEPTS

"We Judge ourselves by what we feel capable of doing, while others judge us by what we have already done." Longfellow

The managerial thoughts and ideas expressed herein are developed specifically for MERDC's Countersurveillance and Topographic (CS&T) Division and takes into consideration its particular environment, scope of authority, and types of problems. It is hoped that the discussions herein will provide a deeper insight into the manager's role for those not intimately familiar with this type of effort, as well as offer a reorientation and some novel concepts for present administrators that could be utilized in the near future. Presently the Army's countersurveillance activities are being appraised very meticulously, especially those of MERDC, thus giving additional emphasis to the need for utilizing the latest management concepts.

By first reviewing some of the major aspects of the countersurveillance environment such as existing management systems, programs, needs, threats, etc., it is hoped that the reader has received a perception into the magnitude of technical and administrative activities that are essential in carrying out a program of this nature. For clear concepts are the initial requirement for the understanding and the effective management of a program of this complexity. To paraphase Peter Drucker, there exists a big difference between doing things right, and doing the right things. For there is nothing quite so useless as doing with great proficiency things which should not be done at all.

The initial approach in perceiving appropriate managerial concepts for the CS&T division should be an organized effort to gain a comprehensive understanding of the priority of work, activities, personal relationships, and required resources expecially at the project level. Then from this knowledge, managerial and administrative procedures can be developed to direct the R&D operations effectively. Therefore, the management concepts contained herein are mainly aimed at the project work level and correlated with the functions of the R&D administrators.

Managers should be fully aware that the scientists and engineers in R&D laboratories are not there primarily to provide jobs for the administrators, nor to do what the latter tell them. The administrators are there primarily to create and maintain an internal environment where it is possible for the scientist and engineer to make their best contributions toward the attainment of organizational goals. Thus proper management emphasis must be placed upon motivation, encouragement, and participation with individual researchers.

It is of little avail to have scientific knowledge, engineering skills, technical abilities, or vast material resources unless the quality of managing organized groups permits effective coordination of available resources. Enterprise functions (the characteristic activities of firms) can not be confused with managerial functions (the characteristic acitivities of managers). Knowledge a manager must have in a R&D organization in order to coordinate the people who have the technical skills includes: which technical specialties are employed in the enterprise function, the role of each, and their interrelationships. But it is not necessary for a R&D manager to possess profound in-depth comprehension of the technical areas.

The division chief is the interpreter of technological trends and requirements for the CS&T division. While the project engineer, at the lower most rung of the management ladder, is both a R&D engineer and manager. In general it is not easy for either one to plan and coordinate activities efficiently because of the uncertainties in R&D work. Also, most of the project engineers do not have management training and therefore are lacking in management skills. Key decisions that are applicable to both levels of administration are: selection of the type of R&D organization or team, it's size in terms of numbers and type of technical personnel, allocation of funds to the projects, major control points, cutoff decisions, and project selection criteria.

Because the functions of a manager in the CS&T division are essentially the same whether he is the project engineer or the first-line supervisor in the division, the management concepts and techniques presented herein are divided into five areas that correspond to the functions which managers perform when they do their jobs:

Planning: selecting from among alternatives objectives, programs, and procedures for achieving them.

Organizing: establishing an intentional structure of roles by determining the activities needed to gain the objectives, grouping and assigning these activities to a manager, delegating the authority to carry them out, and providing for coordination of authority and informational relationships in the organization structure.

Staffing: manning, and keeping effectively manned, the positions provided by the organization structure.

Directing: guiding and leading subordinates.

Controlling: measuring and correcting the activities of subordinates to assure that events conform to plans.[9(p. 6)]

In investigating the various administrative techniques, a practical look has been taken concerning the variables and alternatives of each managerial function in relation to the CS&T division's environment. Thus only those techniques and methods that are suitable and offer potential benefits to the division within the near future are discussed. The approach taken in this thesis is to analyze each administrative function separately, briefly discussing the latest managerial techniques and their limitation and advantages if appropriate, and to describe those activities within the context of the CS&T division.

A. Planning

The first management function that is discussed is planning because it logically preceeds the other functions in time and is a characteristic acitivity of all managers. Plans are important in that they facilitate control, focus attention on the R&D objectives, offset uncertainty and change, and minimize costs by emphasising efficient operations.

R&D planning presents a special problem for the division due to the nature of the R&D process and the limited amount of decision making data available. The establishment of palnning objectives must be a continuous process because the generation of new knowledge from R&D activities opens new prospectives and makes possible new objectives.

The scheduling of countersurveillance (CS) programs and budgets must be flexible in order to incorporate new opportunities. Also, nearer the research end of the CS spectrum, planning is much less specific and is more concerned with the design of information environments that are conducive to feasibility studies.

The purpose of the planning phase is to facilitate the achievement of Army R&D requirements. This phase can be accomplished most effectively by a sequencial planning process consisting of five steps. These steps are: set the planning objectives, establish the premises, determine the alternative courses of action, evaluate and select a course, and formulate derivative plans. Guidelines and constraints that are utilized in these steps are prevailing requirements, policies, procedures, programs and budgets.

As a consequence of the recent emphasis on countersurveillance (CS) by Department of the Army (DA) and the resulting expansion of the countersurveillance and topographic (CS&T) division's research, development, testing, and evaluation (RDT&E) programs and responsibilities as the Lead Laboratory in CS; the division's planning process has taken on a new importance. Within this planning process, the need for a better more reliable, resource allocation and project selection system was vividly recognized. However, in analysing the steps required in the development of a successful planning program, the methods used in establishing premises and making decisions were identified as the major limiting factors. The following discussion will describe these limiting factors, the techniques and methods that are available, their limitations and advantages, and the procedures for their implementation within the division.

1. Premises

Planning premises are the anticipated elements of the environment that might affect the operation of the plan. They include assumptions or forecasts of the future, as well as known conditions such as existing policies, budgets, and programs. The critical factors in premising is not in the present environment but in the future environment in which these plans will operate. This is due to the fact that events in the future cannot be predicted with the same degree of accuracy as elements in the existing environment. However, this difficulty can be narrowed by instituting timely technological forecasting techniques and by having alternative sets of premises and plans based on them.

There are two general approaches to technological forecasting which are of interest to planners of R&D. One is "exploratory" technological forecasting, which seeks to project technological parameters and/or functional capabilities into the future by starting from a base of existing knowledge and projecting new developments and expected technological breakthroughs. The other general approach is "goal-oriented" technological forecasting, in which future goals and missions are identified and assessed as to technological requirements. The process is then worked backward to the present, in order to identify the various technological needs for accomplishing it and perhaps how these might be accomplished. Both approaches can be utilized in assigning priorities to the overall CS effort and in deciding which particular projects to undertake in connection with a specific development program.

Many theories have been developed for R&D technological forecasting and for its use as premises in a resource allocation system. However, most of the more sophisticated techniques developed, i.e. dynamics prediction models, cannot be used in practical situations because the necessary data is not available, too many errors are introduced, or the available data is not representative of the real world. Possibly the best forecasting technique that can currently be utilized in-house is the intuitive method. This method ranges from individual expert opinion polls and panels to the Delphi Technique.

The Delphi Technique has a degree of scientific respectability and acceptance not enjoyed by the other judgment/brain storming approaches. The first step in this method is to select a panel of experts on a particular problem area. Each expert is asked anonymously to make a forecast as to what he thinks will happen, and when, in various areas of developments. Then the answers are compiled and the composite results are fed back to the panel members. With this information at hand, but still with individual anonymity, further estimates of the future are made, and the process may be repeated several times. When a convergence of opinion begins to occur, the results are then used as an acceptable forecast.[10(p. 69-81)]

The need for adequate technological forecasting is apparent from the key part it could play in establishing planning premises within the division. However, it has values aside from this case. The making of forecasts compels the project engineer to look ahead and analyze the future, it discloses the areas where control is lacking, and it tends to unify and coordinate the overall planning efforts.

2. Decision Making

Decision making is the selection from among alternatives a course of action. As such it is at the core of R&D planning. After establishing known goals and clear planning premises, the first step of decision making is the development of alternatives. In this procedure one must recognize the factors that are critical in accomplishing the desired objectives and confine his investigation of alternatives to those which will overcome these limiting components. When these alternatives have been identified, the next step is to evaluate them and select the appropriate course of action.

The most useful way of evaluating R&D alternatives is to utilize the techniques of marginal analysis and cost-effectiveness analysis. Marginal analysis emphasizes the variables (additional costs and other inputs) in a situation and deemphasizes the averages and constants. Cost-effectiveness techniques are utilized when the objectives are in general terms and imprecise, alternatives represent total systems or programs, and decision criteria include least cost, resource allocation, and trade off analysis.

The three most common techniques that are employed in selecting the best qualified R&D alternative are experience, experimentation, and research and analysis. Reliance on past experience probably plays a larger part than it deserves in decision making. However, if experience is carefully analyzed rather than blindly followed and if the fundamental reasons for success or failure are separated from it, it can be useful in testing alternatives and in obtaining empirical data when none exists, but it is expensive and time consuming to use. When major decisions are involved, the most effective and widely used technique should be research and analysis. A common research and analysis method is to utilize the tools of operations research. The basic steps in applying this method are: define the problem, construct a mathematical model, derive a solution from the model, test the model, and provide controls for the solution. Specific mathematical and scientific techniques that assist in management decision making include: probability theory, game theory, queuing theory, linear programming, servo theory, symbolic logic, information theory, value theory, and Monte Carlo methods.

Although there is a great deal of enthusiasm for utilizing these decision making techniques, especially operatings research, specific applications have been limited in the division for a number of reasons. In the first place, a major portion of the managerial decisions involve intangible factors which are difficult to qualify. Next, one is faced with a multitude of complex variables and interrelationships and their difficult mathematical and computing aspects. Another drawback is the lack of understanding between the engineer and operations researcher. This is mainly due to the uniqueness of both fields.

Among the most important newer approaches to R&D decision making under the conditions of uncertainty are: risk analysis, decision trees, and preference theory. Risk analysis attempts to give a more precise view of risk by developing for every critical variable in a decision problem a probability distribution curve. Another way to analyze a decision is by a decision tree which shows the possible outcomes that result from various decisions and other events that are not under the

the control of the decision maker. In order to avoid the individual manager's aversion to or acceptance of risk in decision making, preference theory was developed to supplement the statistically probabilities in decision trees with risk curves that are based on the analysis of the individuals' preferences. Thus giving the resulting probabilities practical meaning in decision making.

The important aspects of these and other formalized methods of decision making are that they provide a basis on which R&D projects can be evaluated, the rational and justification can be repeated or explained, and a dialogue can be opened up between the decision makers and the engineers and scientists. Possibly the most important reason for utilizing a formal procedure in decision making is that it will start people thinking about the future, not simply in terms of a bigger, better program of the same sort in which they are currently involved, but functionally in terms of what their work is for.

3. Implementation

The need for more sophisticated techniques and methods in the planning process of the CS&T division must be measured by the amount they contribute to the planning process as offset by the costs required to formulate and operate them. It is felt that the existing multitude of complex, highly technical CS programs, missions, and responsibilities and those anticipated in the near future more than justify an immediate commitment of technical effort in up grading the existing planning process. Specifically, the areas of technological forecasting and decision making should be defined as a special project.

The successful implementation of this type of R&D endeavor requires a careful consideration of the limitations and capabilities of the CS technological field, user personnel, and existing organizations and CS programs. Probably the most important aspect in developing a concept of this nature is in the selection of the person who will be responsible for conducting the activity. This person should be an expert in system analysis and have a strong background in mathematics and computers, as well as, an acquaintance with R&D procedures. He should also be given a permanent assignment within the CS division due to the long term nature of this project, in order to acquire a general knowledge of the field and a clear understanding of its peculiar problems, and for the day to day coordination of the data gathering aspects of existing programs.

It is envisioned that this effort will be closely coordinated with MERDC's System Engineering and Computation Support Office and with AMC's Cost Analysis Division and Plans and Programs Division. Contracts will be initiated with those companies that have an in-depth understanding of the CS managerial problems and the latest planning methodologies. On-going R&D programs within the division will be utilized for real world data. Tasks 01-Camouflage Measurements and Classification and 02-Camouflage Materials and Measures can provide invaluable information in identifing critical factors in developing decision and forecasting models.

B. Organizing

1. Theory of Organization Structure

The CS&T division's managerial function in organizing is essentially concerned with designing and maintaining an intentional structure of roles that will facilitate the effectiveness of its personnel working toward the accomplishment of R&D objectives. For meaningful R&D roles to exist, this structure should incorporate verifiable objectives, an understood area of authority, a knowledge of the relationships of that role with others, and a clear concept of the major activities or duties involved. According to Leonard Hoelscher, former Deputy Controller of the Army, this organization structure should serve three primary purposes. These are: to enable operations to be accomplished efficiently and effectively; to enable management to be achieved in an effective manner; and to provide an environment which establishes motivation for each individual in the organization to put forth his best effort to attain the enterprise's objectives.[11(p. 305)] In summary, the CS&T division organization structure should be designed to clarify the R&D environment so that every one knows who is to do what and who is responsible for what results.

There is no one structure that is equally good for all groups; nor is there one structure that is good for any one group at all times. Rather, the organization structure must be a response to the division's needs at a particular point in time and to its ability to fulfil these needs. A logical pattern that can be utilized in the development of review of the CS&T division's organizational structure is: establishment of the Army's objectives and requirements; formulation of derivatives RDT&E objectives, policies, and plans; identification and classification of activities necessary to accomplish these; grouping these activities in the light of human and material resources available; and delegating to the head of each group or team the authority relationships and information systems required. For only through a rigorous activities analysis can R&D managers find out what work has to be performed, what work belongs together, and how each activity should be emphasized in the organization structure.

The number of subordinates that a R&D manager supervises is referred to as his span of management. There is a limit to this number; whereby, the exact number of persons depends upon a given situation. Perhaps the major underlying variable in determining this span is the number and frequency of a manager's relationships with his subordinates and his ability to handle them. Factors that influence this contact are: the subordinates' training, the rate of change in personnel, the amount of authority delegated, the time required for planning, the physical location of personnel, the nature of the task managed, and the existing coordination and communication system. These and other limiting variables are what makes distinct levels, or departments, in R&D organization necessary. However, organizational levels are not completely desirable because they are expensive, complicate communications, and hinder planning and control. Therefore, the manager must examine the advantages and disadvantages of a wide span of subordinates with few layers versus a narrow span and many layers. In adopting one course or the other, he must balance the financial cost with the cost in morale, personal development, and the attainment of R&D objectives.

Since an executive cannot manage an unlimited number of subordinates, as pointed out in the discussion above, he forms distinct activity areas or departments. Departments, however, differ with respect to the basic patterns used to group activities. The most common patterns used are: by time, by enterprise function, by territory, by product, by process, by customer, by matrix, and by temporary product. The form that has been widely used in engineering, research, and development organizations is the matrix system.

The matrix form of arrangement is a combination of functional and product patterns with the functional department having permanent status and making available their resources to the projects or products that have limited status. This form of structure has resulted from emphasizing the final R&D product or completed project and having someone responsible for these end results. Of course, this could be accomplished by organizing along product lines, but this has not proven feasible in research or engineering endeavors for a number of reasons. First, the project may not be able to utilize certain specialized technical personnel or equipment full time. Second, the project might be of relatively short duration. Third, highly trained professionals generally prefer to be allied organizationally with their professional group. Fourth, professional people simply will not tolerate the insecurity of frequent organization changes. Lastly, Government technical personnel feel more at home and believe their reputation and advancement will be better if their superior is a professional in the same field.

The major advantages inherent in applying a matrix task-force systems to R&D functions are: a) The research and development department becomes a flatter organization, with fewer people in administrative echelons. b) Discourages empire-building tendencies in individual sections by encouraging participation of specialists from many functional groups. c) Better utilization is made of technical skills throughout the company. d) Professional skills and experience are brought to bear with planned emphasis and timing to reach an optimum solution of the problem. e) Obstacles to success are made apparent at earlier stages. f) A mechanism is provided for effective transfer of perspective, knowledge, and technical know-how by providing continuing participation of R&D individuals who were active in earlier stages. g) By including as consultants individuals who are to be directly involved in later stages, they become identified with the project and are better oriented for subsequent work. h) Professional development of technical personnel is stimulated by association with a wider circle of colleagues and by involvement in a broad range of problems. i) Greater speed in reaching well-rounded conclusions is brought about by coordinating information and opinion from several sources of expertise.[13(-. 5-55)]

The major difficulty that arises from forming the CS&T division's organizational structure based on a matrix pattern is in locating problem areas and identifing the person who is responsible for them. In such cases there tends to be an unusual amount of confusion, friction, and buck-passing. However, this problem can be largely solved by clarifying the authorities and responsibilities within the division of the functional and project/task-force managers.

In the project team, the R&D individuals come from different functional groups and are brought under the leadership of one man. This man, the project team leader, should not have direct authority over the individual members in the usual sense of the word, but only for the control of their involvement in the specific project. Most of the individuals will be operating on a part-time basis at the discretion of the team leader. The rest of the time the members of the team will devote their efforts to other activities to include participation in other task forces.

The task force leader has the responsibility for analyzing his project and diagnosing the need for different specialized R&D skills. He should be given authority over the integrity of the total design, preparing the budget, setting the target dates and program outline, and arranging with the proposed team members and their functional supervisors the personnel scheduling and priorities for the life of the project. On this latter point, if he is unable to work out schedules and priorities on his project because of the claims of another project manager in the laboratory, the matter goes to a higher authority who is primarily responsible for the total technical effort. On the other hand, the functional manager is given authority over the people in his area and over the integrity of research or engineering work done in his functional area.

2. Organizational Change.

The first step in the development of a structure of roles for the CS&T division is an analysis of its current mission, CS programs, and those anticipated in the near future. A brief overview of these areas were discussed under the subheading "Countersurveillance Activities at the Laboratory Level" of this thesis. In retrospect the main event that has taken place within the past year that has had a profound affect upon the CS&T division's programs and missions is a vigorous reemphasis on camouflage by DA resulting in a major expansion of the division's mission to include the function of "Lead Laboratory". This requires the Laboratory's review of all programs within the Command which utilize or involve its technology and to formulate and manage the Command's technological programs within the area of the Laboratory's mission responsibility. Although the Laboratory's end products have deep roots in traditional military doctrine and tactics, the thrust of this new emphasis is on new technology which offers the military new capabilities and dimension.

The principal R&D activities that are required in performing the division's mission and programs were identified, classified, and departmentalized based upon the organizational theories previously presented. These departments and their particular activities are summarized below, while their recommended relationship within the CS&T division is shown in Figure 8.

a. Technology Group Activities. This group is primarily responsibile for conducting research (6.1) and exploratory development (6.2) in the fields of countersurveillance, concealment, deception, and disguise. Efforts in this endeavor include:

Performing a continuing program of research to advance the state-of-the-art and establish a sound technological base.

Indentification and development of the required technical capabilities, facilities, and manpower reservoir of research skills to support in-house task-force teams, as well as foreign panels and committees.

Maintaining liaison with experts in the field.

Developing scientific methodology to analyze and define CS problems in quantitative terms.

Studying and evaluating emerging foreign and domestic science and technology.

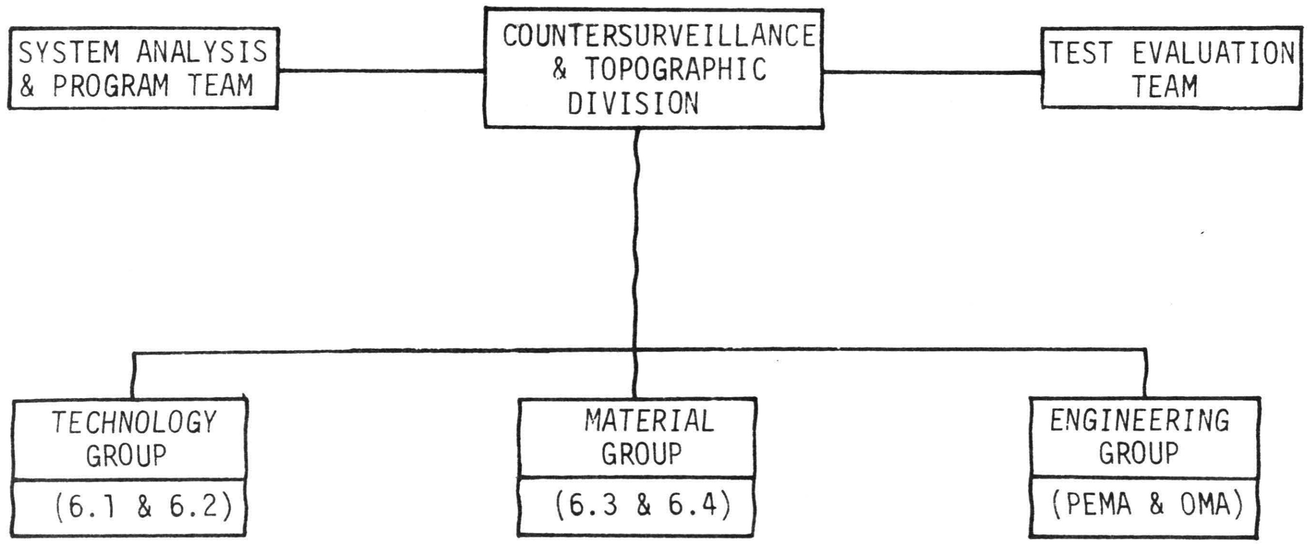


Figure 8. Proposed Structure for CS&T Division

Producing technical handbooks on CS.

Preparing comprehensive plans and analyzing existing research programs for maximum cost/benefits during the immediate, mid and long range periods.

b. Material Group Activities. This group is responsible for executing advance development (6.3) and engineering development (6.4) in the fields of countersurveillance, concealment, deception, and disguise. Work in the group includes:

Conducting continuing advanced and engineering programs leading to type classification actions.

Exploiting the established technological base.

Preparing appropriate Life Cycle Management documentation.

Establishing and coordinating the Joint AMC Camouflage Program.

Providing consultant services to foreign and doemstic bodies.

Exploring and evaluating the cost, benefits and potential of foreign and domestic equipment and materials.

Providing adequate technical expertise and facilities to support in-house task-force teams.

c. Engineering Group Activities. This group is responsible for performing engineering programs and providing engineering support for procurement of surveying, mapping, and camouflage materials for the field army. Activities in this area include:

Establishing the programming and budgeting aspects of PEMA and OMA programs.

Preparing the revising standards, handbooks, and specifications.

Performing actions related to Military Adoption of Commerical Items and Manufacturing Methods and Technology.

Participating in Producing Engineering Planning Studies.

Providing engineering evaluation of changes to CS&T drawings and specifications.

Developing and maintaining the technical expertise required to support in-house task teams and other technical bodies.

d. System Analysis and Program Team Activities. This team is responsible for providing system and program analysis, documentation and requirement services for the division to include:

Establishing and maintaining a CS computer data bank and technical library system.

Providing management information for decision making.

Coordinating with System Engineering and Computation Support Office the development of analytical models for RDTE projects

Providing technical information on system engineering applications and conducting appropriate studies.

Developing and coordinating the division project cost analysis program.

Coordinating with Technical Programs Office on RDTE portion of Life Cycle Management System.

Establishing and operating an integreted planning system.

Coordinating all international programs.

Providing consulting and technical services to project task force teams and other bodies.

e. Test Evaluation Team Activities. This team is responsible for planning, executing, and evaluating the testing requirements of the CS&T division. Efforts in this endeavor include:

Developing evaluation criteria and performing testing services for task-force teams.

Monitoring domestic and foreign contractor tests.

Providing technical application teams for site surveys and technical guidance to related programs, such as project MASSTER and Joint Field Trials.

Operating and maintaining adequate testing equipment and facilities.

Developing new cost-effective testing concepts and techniques.

Participating in the monitoring Development Tests and Operational tests.

Finally, it is recommended that these departments be brought together through a matrix task-force operation system (see Figure 9) which incorporates the authority and functional relationships for each task. This matrix framework emphasis a clear structure of R&D roles in that it reflects the activities to be undertaken, results expected, organization authority delegated, and authority and informational relationships with other operating units. Besides the job enrichment, motivation, etc., aspects of this type of structure, it offers a total "systems" viewpoint and capability within the division.

C. Staffing

1. Overview

The managerial function of staffing within the CS&T division involves manning the organization structure through proper selection, appraisal, and development of personnel. Since positions within the division are filled not only for the present, but for the future, staffing must also deal with the future R&D requirements in its

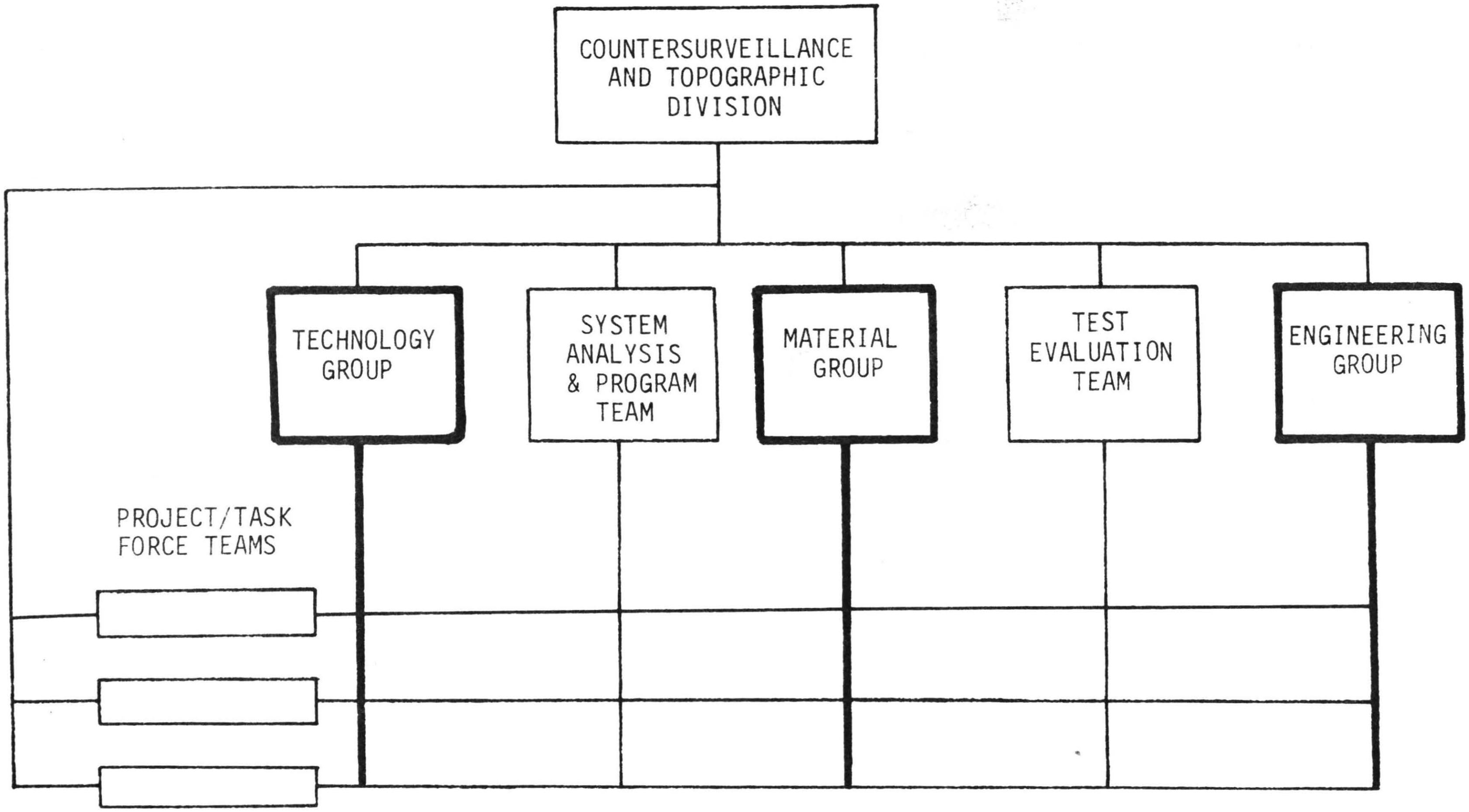


Figure 9. Matrix Task-Force Operation System

organization plan. When the positions and needed talent are identified, the next step is to inventory and appraise existing and potential managerial manpower in the division. Considerations should be given to the division's growth and change, retirements, and probable separations. Lastly, the acquisition of needed manpower should be planned for. This can be accomplished through developing available talent or acquiring personnel from outside the division.

Successful operations and growth in the field of CS is highly dependent on the quality of the division's managers. Some of the most important managerial qualities that should be displayed by a candidate are: a desire to manage, intelligence, analytical ability, ability to communicate, and integrity. The immediate supervisor is usually in the best position to nominate candidates for the front-line supervisor positions. However, most managers within the division resent the loss of promising subordinates through promotion or being routed to other departments for the sake of broadening their experience. Therefore, the need for top-level division involvement is essential for any staffing program to be successful at the project level.

Because the performance of the CS&T division depends largely on the quality of its managers, the selection of these managers is of major importance to the command. Availability is a key factor in this selection process. In theory it is assumed that every qualified candidate in government is available and the best man will be selected. In practice, however, this is quite different. First, there is a wide gap between the information one has on his own candidate versus an unfamiliar candidate. If what is known is not outstandingly favorable, the candidates outside the organization usually have the advantage.

Another condition is whether a likely candidate can really be spared from his present appointment. Also, managers being human rarely make decisions on a rational basis alone, but tend to make them on an emotional basis. Thus the selection may be made because the person will follow the will of the manager, because he is popular, because the candidate has useful connections, or because he enjoys the company of the candidate.

There has long been a reluctance on the part of MERDC's managers to appraise subordinates. These misgivings have arisen from the personal qualities measured, the standards used by civilian personnel people, and very often the way the measurement is performed in the government. However, most people are concerned and interested in their observed performance. Also if a person's strengths and weaknesses are not known, personal development efforts would be haphazard or not performed at all. Therefore, appraisal should be an integral part of managing. For knowing how well a manager plans, organizes, staffs, directs, and controls is the only way to assure that those occupying managerial positions are actually managing effectively.

Managerial appraisal within the CS&T division should measure actual performance in accomplishing R&D goals and plans and performance as a R&D leader. This evaluation has two major parts. One is assessing the performance of managers against their ability to set and achieve verifiable CS objective. The elements of luck, favorable external environment, and other factors beyond the division's control are taken into account in analysing this aspect. The second part is project engineers or program managers are appraised as managers by utilizing as standards the basic concepts and principles of management. If done correctly, appraisal of an individual will result in his knowing what the job is and what end products mark the accomplishment of his job.

Every manager within the division has the responsibility of helping in the development and training of men who have the requisite administrative potential. For most of the division's tasks at the project level require coordination, following procedures, and making decisions. Manager development is the actual progress a manager makes in learning how to manage, while managerial training refers to the specific programs devised to facilitate the learning process. The actual progress is determined by several things. First, the degree of intelligence and the desire to manage an individual. Second, the procedure used in understanding the principles underlying his function and how to apply them. Lastly, the amount of time one spends in actual management positions.

Some of the more prominent techniques for training a manager that can be uitlized by the CS&T division are: Planned progression, job rotation, creation of assistants, temporary promotions, and university management programs. Planned progression is concerned with blue printing the path of promotion for an individual in any given position. This technique usually gives an over optimisitic picture to subordinates, encourages undue specialization, and provides insufficient training. Job rotation refers to a technique for providing diversified training. This is carried out through rotation in non-supervisory work, observation assignments among managerial training positions, and rotation in unspecified managerial positions. The rotation in unspecified positions within the division appears to be the most effective. Its advantages are: it avoids the feeling that the incumbent is on a visit, eliminates the gap between watching and doing, actual experience is obtained in managing CS efforts, resentment of division's subordinates is decreased, and it eliminates the cost of reserving special positions for training purposes.

The assistant position in the division permits the trainee to broaden his viewpoint by exposing him to many areas of managerial practice. However, if the supervisor fails to teach properly, lacks understanding of the assistant's needs, is authoritarian, or is pushed into this relationship, the training will be very poor.

Temporary promotions have many inescapable drawbacks in government R&D organization. First, it is very difficult to hold a person responsible for the performance of a group in the face of so much technical uncertainty. Also, the attempt of a candidate to do something different, such as to reverse a previous decision or to introduce new working relationships, is quite ineffective due to government procedures and the knowledge the orginal boss will return shortly.

2. Implementation

The first step in examining the effectiveness of staffing within the CS&T division is to investigate the current CS programs, organization and the overall mission in order to identify those disciplines that are required. These needed positions or talent are then compared to existing personnel. It is felt that this review would reveal the following disciplines that are essential for more effective R&D

endeavors: system analysis, electrical or electronic engineer, librarian, and a computer expert. A more in-depth analysis or appraisal would disclose the approximate number of personnel required in all areas. However, this would include studying the CS&T divisions past performance, present and future programs and funds, organization, in-house capabilities, project time table and priorities.

Since most engineers and scientists receive little or any managerial training prior to joining the division, it is felt that this area should receive primary emphasis in the development of technical personnel. Even if a person never has an opportunity to be a first-line supervisor, it is of paramount importance to understand the management system in order to perform effectively under it. This is especially important since the majority of the division's work is accomplished through outside contractors and other government bodies. University short courses, as well as, full time training along with unspecified job rotations, seem to be the best approach to this problem.

Since CS is a specialized field in the Army, one must gain an appreciation and understanding of its principles and particular requirements in order to guide R&D efforts. This would include its particular threat, terminology, history, and its state of the art. This can be achieved most rapidly through a review of appropriate literature, discussions with personnel in the field, and courses that relate to the program, such as, the Command and Staff Officer Tactical Cover and Deception course.

The particular aspects of staffing within the CS&T division such as appraisal, selection, and training have been previously discussed. However, one should remember that staffing in R&D is only one part of the management problem and it must be compatiable with and reflect the division's managerial functions of planning, organizing, directing, and controlling. Just knowing various devices and approaches to R&D staffing will not solve the problem. One must understand the philosophy back of it, the tools and assistance needed by the subordinates, and put in the required time and leadership to make them work. As was stated before, the difference in the success of an R&D organization is in the quality of its managers.

D. Directing

1. Nature of Directing

Within the CT&S division directing involves guiding and leading subordinates to understand and contribute effectively and efficiently in accomplishing the groups R&D objectives. This function is best viewed in relation to the divisions objectes in R&D, the productive factors that contribute to those objectives, and the nature of the individuals. For faulty directing within the division can completely nullify all the work that has gone into organizing and staffing it, and can make the attainment of the group's objectives impossible.

Two groups should understand directing. Those who occupy managerial positions within the division obviously need a clear understanding of their duties for a blurred concept frequently results in time lost in non-managerial R&D activities. The second group is the R&D employees who do not manage. Because these persons' goals are derived from the division, they need to feel confident that their managers know how to manage. If, on the other hand, the subordinates believe that their managers "do nothing", it reflects a failure to understand that supervisors accomplish goals primarily by working through others.

The human factor is probably the biggest problem in the division and the least understood. Considerable research and discussions have been forthcoming on this subject during recent years. Perhaps the most noted effort has been by Douglas McGregor in his well-known book "The Human Side of Enterprise". In this book he sets forth two pairs of assumptions on human beings - "Theory X", the autocratic manager and "Theory Y", the permissive manager. However, in the real world managers are not all one or the other, but some place in between. Other noted persons who have studied the human factor in management include: Argyris, Maslow, Schein, and Gibson.

If one sets out to consider the human nature of man, it is quite essential that the whole man comes under review. In this light we may deduce certain operational premises that apply to both the manager and his subordinates when approaching the direction function. These premises include:

The individual is the primary concern of man.

The individual will work to satisfy the demands of his basic nature if the benefits exceed the costs.

The individual can be led.

The individual wants to live and work in a social environment.

The individual helps to create organizations to serve his needs.

There is no average man.

The individual can rise to the challenge of his full capabilities.[12(p. 505)]

It is important to remember that the R&D manager possesses as variable and complex a nature as his subordinates. He is a part of the problem. He brings to work attitudes that are allowed to influence his reactions to events. He is responsible for results and often feels helpless to achieve them in the face of government procedures or due to the technical uncertainty. His spirit rises as he views excellent results and are depressed by overruns or missed milestones.

Another element of directing that should be looked at within the division is the project engineer's relation to his peers and subordinates. Although the project engineer is part of the group, he should not be so identified with his subordinates that he loses his status as a leader of the group, and therefore his distinction as a manager. His leadership style, general character, respect of his peers, and his human attitude influence the morale of his associates, which in turn reflects his skill in directing them.

The three most common direction processes that are used in government are orientation, orders, and delegation of authority. Orientation occurs when the manager provides information necessary for intelligent action. It starts with the introduction of new employees to the work environment and continues through periodic briefings and informal reviews. Orders are enforceable commands that initiate, modify, or stop an activity. They can be informal or formal. Delegation of authority is a more general form of directing than an issuance of orders. In delegation, the superior customarily gives a subordinate authority to act in a large area of affairs by means of a general statement.

The R&D manager must have a positive attitude toward delegating authority and willingly trust his technical subordinates. This does not imply neglect of daily tasks, but errors made in them are turned into object lessons for subordinates and are not looked upon simply as catastrophes. Errors are, of course, minimized by appropriate safeguards. Subordinates should be encouraged to accept authority and the superior must be available and permit the subordinate to utilize his knowledge. Finally, the R&D manager must show patience in the managerial development of subordinates.

2. Motivation

The unique nature of research is such that outputs of R&D efforts cannot be matched literally with inputs of dollars or man-months of time. Technological break throughs, new material concepts, and the time frame for material development are closely related to an organization's innovative capability and their ability to fully utilize existing resources. In this light it is imperative that employees and manager within the CS&T division be motivated to initiate and carry through R&D programs and ideals that are efficient and effective in terms of resources commited versus results obtained.

Motivation is by no means a science. Historically the prevalent assumption was that employees or supervisors could motivate subordinates and should be held responsible for doing so. This view would be limited by existing government policy on salaries, fringe benefits, and promotions, just to name a few. However, it is desirable to seize upon what is known about man and what appeals to him and try to establish a motivation system that will focus his actions on the results desired.

Whatever the motivation system is, it usually contains certain characteristics. It has to be productive in the sense that the results it yields are in excess of the cost. The system has to provide competitive rewards so that managers of desired caliber will be attracted and retained. It should also be comprehensive in the sense that there will be a variety of rewards appealing to each individual manager. Lastly, the motivators can be both positive and negative. Some of the most common motivators used in R&D are the need for security or to be free from anxiety, the promise of recognition, the need for stimulation or the avoidance of boredom, increasing a person's control over the job, and the provision of opportunities for employees to prepare themselves for greater responsibilities.

There appears to be much mystery about creativity in an R&D environment. Motivation is sometimes perceived as the key to creativity and there is often the mistaken notion that managing itself tends to stifle it by placing heavy demands on conformity. Creativity may be essentially equated with innovation as an instance where an individual puts together two or more known elements in a combination that did not exist before. Thus it is widely agreed that creativity arises when there is a problem to be solved and the problem is seen in the light of the critical variables involved and their relationships. Often the realization and seeing the problem are the true innovative acts and the answer is the easier part of the process.

In encouraging creativity within the division, two facts should be recognized. First, creativity is not a rare human quality, although highly significant creativity is a much more rare achievement. Secondly, creativity is largely a matter of placing a person in an environment where he can be creative, where he can recognize the existence of problems, and where he will have the authority and resources to solve them. In order to better relate and understand the directing functions within the division, managers should periodically review and discuss those characteristics of leadership, motivation, and creativity that can be improved.

3. Leadership

Leadership is a principal element in the direction function. It is the art of inducing subordinates to accomplish their assignments with zeal and confidence. The leader acts to help a group attain its objectives with the maximum application of their capabilities. He does not stand behind a group to push and to prod, but he takes his place before the group as he facilitates their progress and inspires them to accomplish the company's goals.

Few employees within government work with continuing zeal and confidence due to a lack of motivation, adverse environmental circumstances or mediocre managers. These employees, as well as the self-starters would benefit from a manager who is skilled in the art of leadership. This skill has two major ingredients - the ability to invent and use appropriate motivators, and the ability to inspire. For it is one thing to know the categories of motivators and quite another thing to identify the individual's needs, to define ways to satisfy them, and to administer the motivators in a manner that will ensure the desired response.

Perhaps the fundamental principle of leadership that is most applicable to the division is that since technical people tend to follow those in whom they see a means of satisfying their own personal goals, the more the division managers understand what motivates their subordinates and how these motivations operate, and the more they reflect this understanding in carrying out their R&D activities, the more effective as a leader they are likely to be.[12(p. 559)] The necessity for synchronizing R&D actions arises out of differences in opinion as to how group goals can be reached. It thus becomes the central task of the division's group managers to reconcile differences in approach, timing, and effort. The division managers must understand both the role of each skill employed and the interrelationships between skills. They must clearly define and communicate to everyone the dominant goal and mission of the division.

Possibly the most recurring leadership problem within the division is change. In his function of directing, the division managers must strive to overcome resistance to change. Employees have always feared the unknown because they do not know how the change would affect them. Thus the managers should prepare an explanation of the purpose of the change, its timing, and the anticipated organizational effects and communicate it to their people as far in advance of the change as possible. Then, they should allow time for their subordinates to get used to the idea and to answer questions pertaining to it.

Another pitfall in leading people is the misinterpretation by subordinates of the leaders' attitudes. Every word and action of a manager are watched closely for signs of his opinion. When the boss scowls, complains, or smiles, the over-self-conscious subordinates may assume that these signals are meant for him. Another kind of misinterpretation is when the manager concentrates on matters that need special attention, while lessening his interest in matters that are proceeding well. The subordinate is therefore apt to concentrate his efforts on whatever the manager is looking at to the point of neglecting his other duties.

E. Controlling

1. Process of Controlling

The CS&T division's function in controlling RDT&E activities is in the measurement and correction of their performance. In this light, the process of controlling is dependent on the division's previous planning efforts to the extent that the R&D plans establish the overall criteria for evaluating performance. But, controlling involves much more than the mere measurement of deviations from plans. For effective control includes the design of control devices and information systems to fit a particular plan, organization, and needs of the manager. True control implies that corrective action can and will be taken. Within the division, these actions may involve simple measures such as minor changes in plans and objectives. While in other cases, adequate control may require major changes in the organization structure, staffing, or method of directing.

The primary responsibility for developing a control system rests with the manager charged with accomplishing the division's objectives. This basic process involves three steps: establishment of standards, measurement of performance, and correction of deviations. In addition there are a number of considerations that one should keep in mind. First, controls in R&D must reflect the nature and needs of the task. Second, controls should report deviations from the operating plan promptly. Third, controls should be forward looking. Fourth, controls should point up exceptions at critical points throughout the R&D cycle. Fifth, controls should be objective. Sixth, controls should be more flexible at the research end of the spectrum. Seventh, controls should reflect the organization pattern. Eighth, controls should be economical. The cost in time and money should not outweigh the gain in project performance. Ninth, controls should be understandable by the project engineer and the supervisor. Tenth, controls should lead to corrective action.[12(p. 586-590)] Perhaps the most important requirement in a project control system is some form of feedback.

Standards in R&D are established by expressing programs in terms of critical control points or milestones in order that the actual or expected performance can be measured against them. In general, standards are of the following types: physical, cost, capital, revenue, program, and intangible. However, with the present tendency of R&D organizations to establish qualitative and quantitative goals, the use of intangible standards is diminishing.

The traditional control devices for measuring performance include various types of budgets, statistical data, special reports, break-even point analyses, internal audits, and personal observations. The two most often used in R&D are budgets and personal observations.

Budgeting is the formulation of plans for a given time frame in financial terms. Since budgets are expressions of plans and the typical organization has a large variety of plans, there are many types of budgets. However, there are many dangers in budgeting. One is in overbudgeting. This spelling out of minor details makes budgets cumbersome, meaningless, expensive, and deprives the manager of freedom in operating his department. Another risk lies in allowing budgetary goals to supersede R&D goals. One more hidden danger sometimes found in budgeting is that of hiding inefficiencies, i.e., basing the future budget on past expenditures and requesting for more than is needed due to past budget cuts. Perhaps inflexibility is the greatest hazard in controlling through budget cuts. This is because an inflexible budget causes: employee resentment to the point of reduced enthusiasm; a tendency for R&D groups to concentrate only on conservative approaches; an unrestrained spending of surplus funds remaining at the conclusion of a project; and research performance to conform with original budget estimates rather than on technological achievement.

If budgetary controls are to work, they should only be used as a tool of planning and control, and all managers expected to administer and live under them should have a part in their preparation. Also, budgets should not be over emphasized to the extent of seriously compromising the authority of managers. One of the key elements in eliminating this is to develop and make available standards by which the manager's work can be translated into needs for manpower, operating expense, space and other resources. Lastly, if budgetary controls are to work, the manager needs information designed to show him his actual performance and a forecast of the future.

While budgeting is useful in the planning of an R&D program, it has questionable value in the control of R&D costs and the measurement and evaluation of R&D output. Within recent years, the government has utilized a time-event network analysis called PERT (Program Evaluation and Review Technique) and its companion network technique CPM (Critical Path Method) for controlling research and development programs.

PERT breaks a project down into activities, time schedules to accomplish the activities, milestones, and the relationship between the milestones and tasks. This description of PERT is called PERT/TIME and has led logically to the development of PERT/COST with the application of costs to activities in the PERT network. CPM in more of a deterministic technique, but its methodology is the same as PERT. In recent years, one hears little or nothing in military contracts or companies about PERT or CPM. What has happened is the specialists in the field promised too much and users became disillusioned. However, setting up the network, its analysis, its interpretation, and reporting from it probably requires no more expense than most other planning and control techniques.

The most widely publicized tool of planning and control is the program planning and budgeting system (PPBS). PPBS is basically a means for providing a systematic method for allocating the resources of an enterprise in ways most effective to meet its goals. By emphasizing goals and programs to meet them, it eliminates the ordinary weakness of other types of budgets. It has particularly offered great potential and actual benefits in government and is employed in all federal departments. Departments in which the PPB system has been a success have given: attention to teaching the system to managers and staff at all levels who are expected to operate under it; emphasis on developing verifiable program objectives and consistent planning premises; modified accounting systems to fit programs rather than line activities; and modified organization structures to fit the programs.

The third step in the control process is correcting deviations from plans. The normal procedure is to trace the cause of the problem back to the person responsible for it and get him to correct his actions. This procedure is called "indirect control". The alternative is to develop better managers who will skillfully apply learned concepts, techniques, and principles and thus eliminate undesireable results caused by poor management. This is called "direct control".

Indirect control measures may be impractical in the face of a high degree of uncertainty or lack of knowledge or judgement that are usually associated with R&D projects. At best, indirect controls have a low ratio of success in R&D and a high cost of attainment. In addition to its cost, the short comings of indirect control rest on questionable assumptions i.e. performance can be measured, personal responsibility for performance exists, mistakes can be discovered in time, and the person responsible will take corrective steps. In contrast, the assumptions on direct control are: that qualified managers make a minimum of errors; that managerial performance can be measured; and that the application of management principles can be evaluated.

2. <u>System Formulation</u>

In light of the managerial principles and techniques in controlling previously discussed, a concept for governing the over-all performance of the CS&T division will be presented. The main emphasis during the development of this conceptual system was on the utilization of existing procedures, policies, and reporting documents. Another guide was the maintenance of a balenced environment for creativity and conformity. Lastly, this controlling system takes into account the increased sophistication in managing; especially, the use of electronic data processing, direct costing, planning and decision making.

Since most of the R&D goals within the division are accomplished through a project team, the thrust of this controlling system is focused on the project leader. Included in this study were: the amount of time required in operating the system particularly by the project leaders; ease of understanding by the technical personnel and managers; the motivational effects; and the total cost versus the system's contributions. Existing information documents that are currently utilized by divisional personnel include: Work Unit Status Reports, Fiscal Status Reports, Operating Plans, RDTE Program Data Sheets, and Research and Development Planning Summaries. A computerized evaluation system call Task Status Report System has been conceptualized to assist in the control function. Task Status Report System is visualized as a computer system that evaluates the actual performance of tasks or projects in comparison to past or current planning criteria. Each project is graded individually and ranked by priority if its deviation exceeds established standards. The performance of the division as a whole is stated each quarter in the fiscal year and monthly throughout the year. The Task Status Report System stresses the status of milestone accomplishment, task completion, and funds expended. It is compatible with existing information systems and with the matrix task-force system recommended previously.

Task Status Report System utilizes three main inputs - initial input data, monthly input data, and control input data. The relationships between these inputs is shown in Figure 10. An explanation of who is responsible of what input data and examples of each is given in the following paragraphs. It should be kept in mind that the computer programming, key punching, and data storage is performed by MERDC's Computer Center.

a. Initial Input Data. This data is derived by the task leader or project engineer from the appropriate R&D planning documents and takes into consideration available in-house technical man power and facilities. The planning documents of greatest significance that are utilized by the CS&T division are the Research and Development Planning Summary, RDTE Program Data Sheet and MERDC's Operating Plan. With this information, the task leader estimates the monthly progress, milestones, and cost based on his personnel R&D experience and discussions with others in the field including outside contractors. This estimate is reviewed by the program chief who is normally the task leader functional group chief. Upon reaching agreement the monthly estimate for the completion of the project is submitted to the Computer Center for input into the Task Status Report System. An example of this type of input data on one project for a seven month time period is given in Table II. The milestones are derived by reviewing a standardized division list of milestone completions. As an example, some of these are: contract awarded (A), feasility study accomplished (FS),

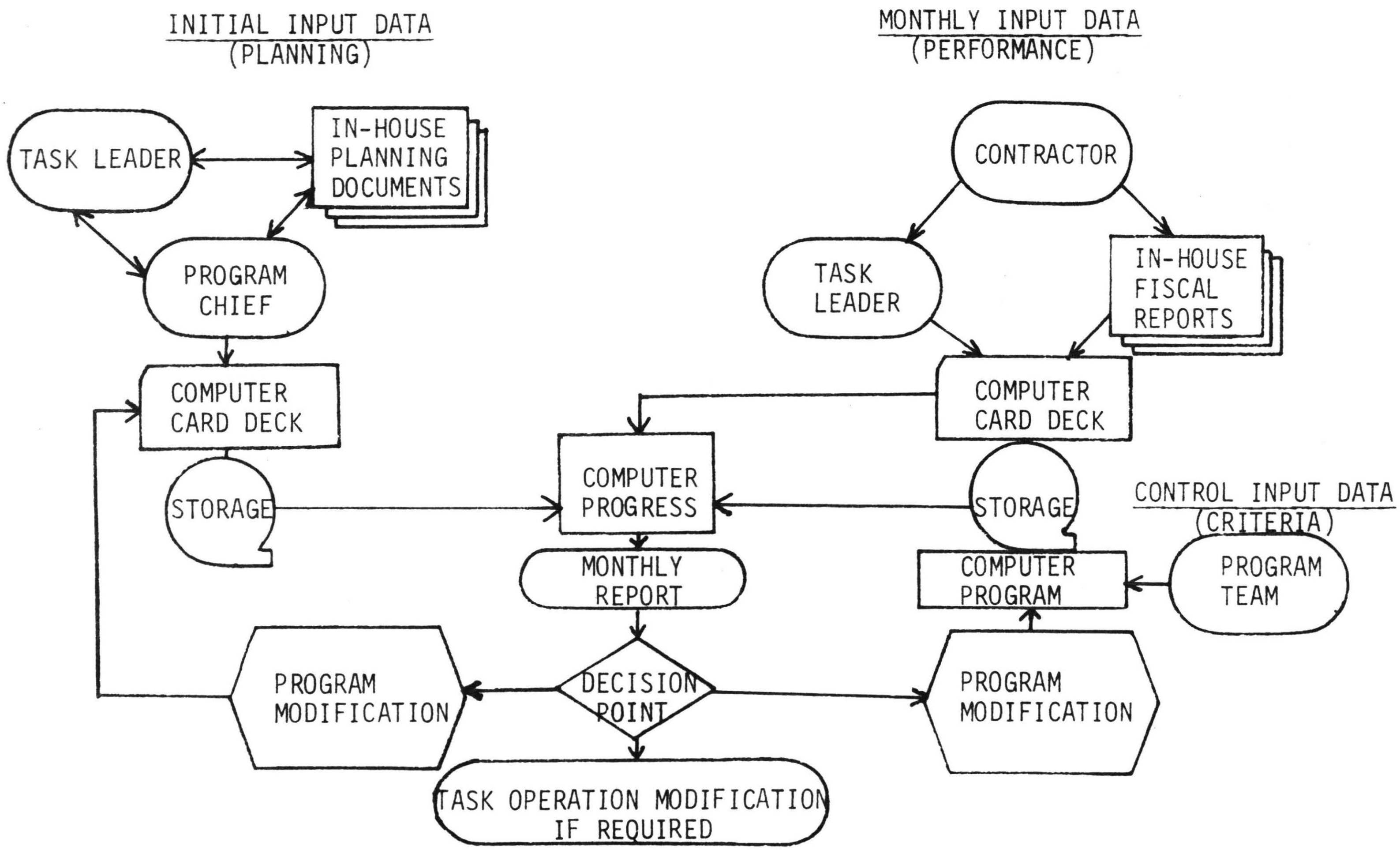


Figure 10. Task Status Report System Flow Diagram

Table II. Initial Input Data

PROJECT NUMBER	TASK TITLE	PROJECT ENGINEER	FUNDS AUTHORIZED
62708DJ17-01	CAM MEAS & CLASS	JOE ROBERTS	$12,206

Fiscal Year 73	JUL	AUG	SEP	OCT	NOV	DEC	JAN
PROGRESS	5%	3%	8%	10%	12%	18%	21%
COST:							
IN-HOUSE	$175	$400	$300	$200	$ 75	$100	$ 150
CONTRACTOR	-	-	750	1100	1600	2100	3000
MILESTONES	A	-	P&D	-	-	G	-

prototype fabricated (P), engineer design test completed (EDT), etc. This milestone list is reviewed and updated by the division's program chief.

b. Monthly Input Data. This data is compiled by the task leader and program secretary. The task leader is responsible for estimating the actual monthly progress in conjunction with an outside contractor. This information, including the contractor's monthly cost, is given to the program secretary who combines it with project data from MERDC's Monthly Fiscal Status Report. Information from the Fiscal Status Report includes the actual and cumulative monthly cost on: labor, travel, materials, and technical support. It also gives the total in-house and external costs. An example of this form of input data is shown in Table III.

c. Control Input Data. The Computer Center derives this data from the criteria designated by the division chief. This criteria specifies how much to weigh each project and is composed of a range of figures for each weighted factor. These factors are: interest by higher authority; other project dependency; deviations in cost, progress, or milestones; and the amount of funds authorized. An example of how this weighed factor is derived is shown below for a specific project.

Interest factor = 3.0

Project dependency = 1.7

Table III. Monthly Input Data

PROJECT NUMBER	DATE	PROJECT ENGINEER	PROGRESS	MILESTONES
62708DJ17-01	6SEP73	Joe Roberts	4%	

COST:	LABOR	TRAVEL	MATERIALS	TECH SPT	TOTAL IN-HOUSE	EXTERNAL	GRAND TOTAL
ACTUAL	$ 75	$125	$60	$ 70	$430		$400

Deviations:

$$\frac{\text{Actual Cost}}{\text{Estimated Cost}} = \frac{45}{30} = 1.5$$

$$\frac{\text{Estimated Progress}}{\text{Actual Progress}} = \frac{30\%}{15\%} = 2.0$$

$$\frac{\text{Milestones Estimated}}{\text{Milestones Completed}} = \frac{2}{1} = 2.0$$

$$\frac{\text{Project Funds}}{\text{Total Division Funds}} = \frac{200}{5100} \times 100 = 3.9$$

TOTAL WEIGHED FACTOR = 3.0 + 1.7 + 1.5 + 2.0 + 2.0 + 3.9 = 14.0

This weighed factor is compared to each project that needs management attention and then each project is ranked in priority. The computer determines which projects need attention by calculating their performance ratios and comparing them against a standard. Performance ratios include: funds spent versus estimated, progress made versus estimated, milestones completed versus estimated, percent progress versus percent cost, and man hours spent versus man hours estimated.

d. Monthly Output Report. This report is given to the division chief and each project engineer. It gives the performance of each project, as well as, the division's performance as a whole. The Monthly Output Report is broken down into three parts - Division Totals, Projects that Need Management Attention, and Individual Projects. This report is shown in Table IV, and is described below.

1) Division Totals -- The estimated and actual percentage of progress are given each month and the cumulative for the

Table IV. Monthly Output Report

COUNTERSURVEILLANCE AND TOPOGRAPHIC DIVISION TASK STATUS REPORT
AUGUST (1 QTR FY 73) (09/09/73)

DIVISION TOTALS

	PROGRESS		IN-HOUSE COST (ths)		EXTERNAL COST (ths)		TOTAL COST (ths)	
	MO	CM	MO	CM	MO	CM	MO	CM
ESTIMATED	9%	17%	46	204	390	652	436	856
ACTUAL	7%	12%	40	183	480	805	520	988

FISCAL YEAR 1974	1 Qtr	2 Qtr	3 Qtr	4 Qtr
Budget Authorization	1,100K	1,500K	1,400K	900K
Funds Spent	988K	-	-	-

MILESTONES	
ESTIMATED	46
COMPLETED	38

PROJECTS THAT NEED MANAGEMENT ATTENTION

PRIORITY	TASK TITLE	PROJECT ENGINEER	FUNDS AUTHORIZED
1	FIELD DECOYS	BILL JONES	$ 678K
2	IR REFLECTORS	JOHN ABLE	$ 52K

INDIVIDUAL PROJECTS

PROJECT NUMBER	TASK TITLE	PROJECT ENGINEER	FUNDS AUTHORIZED
62708DJ17-01	CAM MEAS & CLASS	JOE ROBERTS	$12,206K

	PROGRESS		IN-HOUSE COST		EXTERNAL COST		TOTAL COSTS	
	MO	CM	MO	CM	MO	CM	MO	CM
ESTIMATED	3%	8%	$400	$600	-	-	$400	$600
ACTUAL	4%	9%	$430	$575	-	-	$430	$575

COST:	LABOR	TRAVEL	MATERIALS	TECH SPT	TOTAL
ACTUAL	$ 75	$125	$30	$ 70	$400
CM	$175	$245	$60	$220	$600

fiscal year. Likewise a monthly and cumulative fiscal year report is given on in-house, external, and total costs. Also included are the budget authorization for each quarter of the fiscal year and the cumulative funds spent during the fiscal quarter. Lastly, a cumulative account is presented on milestones completed versus milestones estimated.

2) Projects that need Management Attention. -- If a project's performance deviates from an established range, it is ranked in priority in this section based upon its weighted factor. Other information that is furnished here includes task title, the name of the project engineer, and the total amount of funds authorized for the project. The number of projects listed in this section is not limited to any specific number.

3) Individual Projects. -- Each project in the division is listed in this section in numerical order according to its project number. Included in this project identification is the task title, the name of the project engineer, and the total amount of authorized funds. Project data includes the estimated and actual percent of progress, in-house cost, external cost, and total cost for the month and its cumulative. Also contained in this block is the in-house cumulative and actual monthly cost of labor, travel materials and technical support.

V. CONCLUSIONS

The advantages of good management are commonly known by most individuals; however, the specific implementation of any management program requires a knowledge of the existing environment to include its organizations, programs, technical skills, resources, and personal relationships. This thesis provides the reader with a background on the activities of the Countersurveillance and Topographic Division, existing Government research and development administrative procedures, and the needs and requirements for countersurveillance in the Army. It also furnishes management concepts and techniques that offer a marked improvement in the overall performance of the division.

It is specifically advised that the Countersurveillance and Topographic division implement the following recommendations:

All employees and managers become intimately aware of the full spectrum of activities in countersurveillance to include both the technical and administrative fields.

Technical efforts in technological forecasting and decision making be highly upgraded and broken out as a separate task.

The matrix task-force system be implemented for all R&D projects.

The present organization be expanded to include a Test Evaluation Team and a System Analysis and Program Team.

A system analyst, librarian, computer expert, electrical or electronic engineer(s) be employed.

All managers review and discuss periodically the characteristics of effective leadership and motivation that are applicable to the division.

The concept of "direct control" be followed to include active participation in the development of all employees.

Task Status Report System be installed to provide managerial information to project leaders and middle management.

These recommendations are relevant to the mid-70's time frame and form a firm basis for future management planning. In terms of money and time, they represent the most feasible steps to achieving a high probability of increasing the performance of the division; especially, at the project level.

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VITA

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APPENDICES

APPENDIX A

DEPARTMENT OF THE ARMY REGULATIONS

TOPIC	REFERENCE
Combat Development Process	AR 71-1
Configuration Management	AR 70-37
Development Plan	AR 70-27
Life Cycle Management	AR 1000-1, DA Pamphlet 11-25
Management Accounting for the RDTE Appropriations	AR 37-112
Management Control System	AR 37-200
Management Information System	AR 18 series, DA Pamphlet 18-5
Management Process for Development of Army Systems	DA Pamphlet 11-25 AR 1000-1, AR 71-1
Operational Test and Evaluation	AR 71-3, AR 71-8
Plans, Army	AR 1-1
Program & Budget, RDTE	AR 70-6, AR 37-112
Program Memorandum	AR 70-27
Project Management	AR 70-17
Reporting of Planned and On-going Work	AR 70-9
Requirements Documents for Material Development	AR 71-1
Responsibilities, Army Staff and Major Commands	AR 10 series
Studies	AR 5-5
System Management	AR 70-17

Topic	Reference
Technical Data-Requirements and Procurement	AR 700-51
Work Breakdown Structures	AR 70-32

APPENDIX B

COUNTERSURVEILLANCE REFERENCE MATERIAL

Field Manuals (FM)

	FM 5-20	Camouflage Basic Principles and Field Camouflage
	FM 5-22	Camouflage Materials
	FM 5-23	Field Decoy Installation
	FM 6-121	Field Artillergy Target Acquisition
	FM 6-122	Artillery Sound Ranging and Flash Ranging
	FM 20-60	Battlefield Illumination
	FM 21-75	Combat Training of the Individual Soldier and Patrolling
	FM 24-1	Tactical Communication Doctrine
	FM 30-5	Combat Intelligence
	FM 30-17	Couterintelligence Operations, Intelligence Corps, U.S. Army
	FM 30-20	Aerial Surveillance - Reconnaissance Field Army
(C)*	FM 31-40	Tactical Cover and Deception
	FM 31-60	River Crossing Operations
(C)	FM 32-20	Electronic Warfare (Ground Based)
	FM 44-1	U.S. Army Air Defense Artillery Employment
	FM 55-4	Transportation Movements in Theaters of Operations

Training Circulars (TC)

TC 30-1	Tactical Cover and Deception
TC 101-2	Tactical Operations Center

Army Training Programs (ATP)

ATP 5-97	Engineer Camouflage Company
ATP 20-5	Field Exercises and Maneuvers

Army Subject Schedules (A Subj Scd)

A Subj Scd 5-1	Concealment and Camouflage
A Subj Scd 30-1	Tactical Cover and Deception
A Subj Scd 30-9	Combat Intelligence

(C)* Confidential Classified Material

Army Training Tests (ATT)

ATT 5-97	The Engineer Camouflage Company

Tables of Organization and Equipment (TOE)

TOE 5-976	Engineer Camouflage Company

Technical Bulletins (TB)

	TB ENG 77	Construction of Field-Expedient Decoy Floating Bridges
	TB ENG 143	Paratrooper Decoy
(C)	TB ENG 146	Simulation Device, Fighting Equipment Set No. 1, Generator-operated, Assault, Bivovar and Convoy Portable.
(C)	TB ENG 147	Decoy Lighting Set No. 2, 4500 Foot Airstrip Portable.

Technical Manuals (TM)

TM 5-200	Camouflage Materials

Training Films (TF)

TF 3-2732	Employment of Smoke in Combat Operations
TF 3-2733	The Chemical Smoke Generator Company
TF 5-2976	Camouflage - Part I
TF 5-2877	Camouflage - Part II
TF 5-3881	Individual Camouflage
TF 5-3882	Small Unit Camouflage
TF 21-1370	Camouflage - Movement of Individuals and Small Units
TF 21-2097	Camouflage Principles
TF 21-2098	Individual Concealment
TF 21-2099	Concealment of Vehicles
TF 21-2100	Concealment of Bivouacs
TF 21-2197	Camouflage for Scouting and Patrolling
TF 32-4059	Airborne Radio Direction Finding System

Miscellaneous Films (MF)

MF 30-8439	Armies of the World - The Soviet Army - Camouflage

<u>Film Strips (FS)</u>

FS 5-67	Individual Camouflage and Concealment
FS 5-107	Use of Field Decoy Installations
FS 5-165	Camouflage Drape Net Set
FS 21-6	Concealment Against Air Observation

<u>Film Bulletins (FB)</u>

FB 5-85	Camouflage Dummies and Decoys

<u>Graphic Training Aids (GTA)</u>

GTA 5-1	Concealment and Camouflage
GTA 5-3	Camouflage Series One
GTA 5-4	Camouflage Series Two